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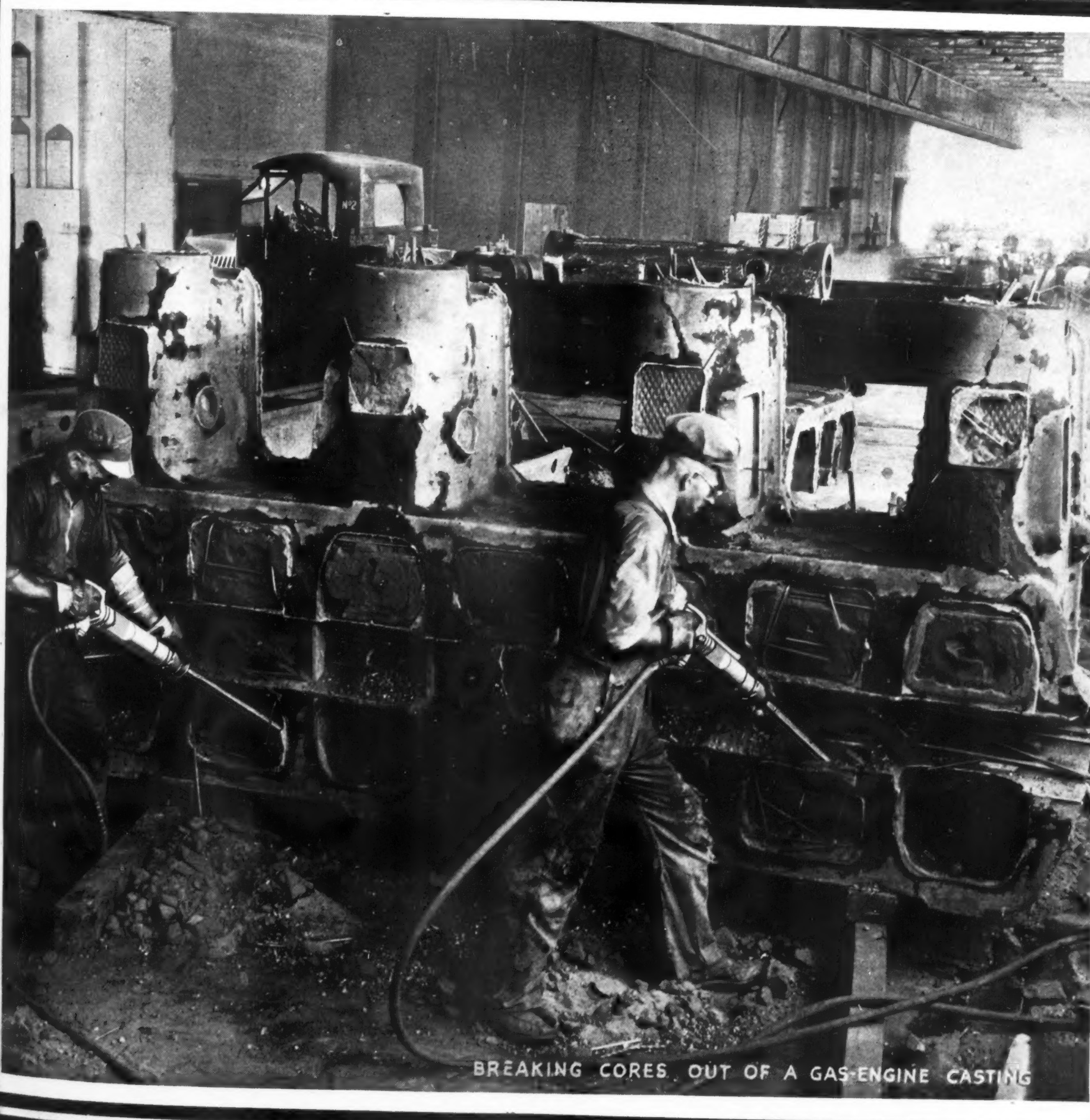

A Monthly Publication Devoted to the Many Fields of Endeavor in which Compressed Air Serves Useful Purposes

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# Compressed Air Magazine


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# Ancient Engineering and Quarrying

John C. Belknap

Photos Ewing

THE SILENT GUARDIAN OF THE NILE

The Great Sphinx of Giza looks due eastward from the pyramid field over the Nile Valley. This creation of rock, with its inscrutable human face and animal forepaws, is the most famous of the many sphinxes built by ancient peoples. It is 189 feet long. According to an inscription on the shrine between the paws it represents the sun god Harmachis.

AS we speed across country in a modern automobile or train, or skim through the sky in an airplane, many of us marvel over the conquests of present-day engineering. So much so, in fact, that we are likely to discount the accomplishments of past ages. It is generally recognized, for example, that the man that did most to promote travel was the inventor of the wheel. Wheels are such commonplace articles nowadays that it is difficult for us to realize that they did not always exist. The truth is, however, that all heavy loads were once dragged over the ground, probably on skids or crude sleds. Then one day some unknown man—perhaps a hairy, beetle-browed fellow in a dirty animal skin—conceived the idea of the wheel. Forthwith, transportation was revolutionized.

In appraising the engineering achievements of the ancients, we must bear in mind that they had extremely little in the way of tools, equipment, or knowledge to help them. Considering the fact that they overcame great obstacles in spite of these shortcomings, some of the things they did will stand favorable comparison with modern feats. Take the pyramids, for instance. Even today no one is quite sure just how they were built. The quarrying of the huge blocks of stone was in itself an amazing exploit, to say nothing of the means used for their transportation and construction.

Any one that ponders all this may have many of his questions answered if he will visit a good library. In addition, he will be rewarded by some enthralling reading matter. In their *History of Engineering*, Fleming and Brocklehurst have presented a satisfactory explanation of the quarrying and moving of the tremendous blocks of stones that went into the pyramids. As the reader peruses the pages of this book, modernity fades away and he finds himself transplanted into a world that existed centuries ago. In these surroundings, he sees con-

## HYPOSTYLE HALL AT KARNAK

The Temple of Karnak was the work of many monarchs. It was started about 1550 B.C. and was still being added to under the Ptolemies from 323 to 30 B.C. The sanctuary and surrounding chambers were built first. Afterward came many halls, the roofs of some of which rested on pillars of stone. The ruins of a group of these supporting columns are shown here.

## BUILDING THE TEMPLE AT WARKA

An artist's conception of work as it was carried on by the ancients. The Temple of Warka was one of the pyramid-like structures known as ziggurats that were constructed by the early Babylonians between the Tigris and Euphrates rivers. They were located along what was then the shore line of the Persian Gulf, which is now 140 miles farther south. Ziggurats were temples with each succeeding story set back from the one beneath it, forming a series of terraces. They were reared on mounds of earth to protect them against possible inundation. This was the practice with respect to all buildings; and entire towns were so elevated. The cities have vanished, but in a stretch of 220 miles there remains a series of mounds some of them a mile square. After 3,000 years or more they are still the most conspicuous features of the flat country.

## STONE THAT WAS NEVER DELIVERED

This great block of rock, measuring 12x15x70 feet, lies near the ruin of the Roman Temple of Jupiter at Baalbek, Syria. It was apparently intended for shaping into a column, but for some unknown reason it was abandoned. Baalbek is located about 35 miles from Damascus and was known to the Greeks as Heliopolis, one of the most ancient cities of Egypt. It was the principal seat of sun worship, and is mentioned in the Bible under its native name of On.

struction projects in a different light. Things were then not built for a price. There was no rushing of the work to have it finished by a definite date. There were no costs to be counted. There was little or no private enterprise. All large undertakings called for the services of thousands of people, and they were paid out of the public treasury. According to Herodotus, the Great Pyramid, largest of them all, kept 100,000 men occupied for twenty years. Thirty thousand men worked on King Solomon's Temple at Jerusalem.

The directing of such vast numbers of men must have been a colossal job. How their efforts were coördinated and made to produce some of the most accurate, large-scale engineering works defeats our intelligence. To illustrate, the book referred to tells us that "the Great Pyramid has a base 764 feet square, and originally rose 480 feet in the air. The weight of this mass is measured at approximately 6,840,000 tons. Many of the individual stones weigh between 40 and 60 tons, and the granite blocks roofing over the central sepulchral chamber are nearly 19 feet long, from 3 to 4 feet deep, and 2 feet broad. The accuracy of the work of the Great Pyramid is such that the four sides of the base have a mean error of only six-tenths of an inch in length, and twelve seconds in angle from a perfect square."

As another of the many examples of herculean labor performed at a time when workmen had only the most primitive of tools to help them, there should be mentioned the great Temple of Karnak near ancient Thebes. This structure, in its ultimate form, was built during a succession of dynasties beginning with Thothmes I in 1550 B.C. and ending during the Ptolemaic period between 323-30 B.C. Like all temples of that day, it was approached by a long avenue of sphinxes leading through a main gate to a spacious outer court and thence into the temple proper. Its dominant feature was the first hall or "hypostyle," where the people assembled, and this was followed by a number of other halls that decreased in size and height until the sanctuary was reached.

The hypostyle hall, or hall of columns, was constructed during the reign of Seti I, and had inside dimensions of 329x170 feet. It contained 134 pillars—67 on each side of a central aisle flanked by twelve columns each 70 feet high, the tallest of them all. The reason for this extra height was to raise the normal roof level and to light the chamber, the "windows" in the clerestory so formed being large rectangular openings filled with pierced stone trellises. Ruins of

**ONE OF A HUNDRED GATES**

**Herodotus called Thebes the "City of a Hundred Gates." These structures were erected as portals to the Temple of Karnak, one of the great ancient ruins that draws thousands of tourists to the banks of the Nile each year. The gate is as high as a good-sized office building. It was constructed 23 centuries ago by Euergetes I, who was also known as Ptolemy III.**

some of the great pillars of the Temple of Karnak are still standing as a reminder of one of the world's greatest architectural achievements.

To return to the *History of Engineering,* it tells how the Egyptians quarried, transported, and erected the huge blocks of stone they used for obelisks. Here again is seen the hand of genius. A genius, at least, for he applied to his needs that which he learned from observation. Probably from very early times it was known that wood immersed in water would swell. But how many people, even today, would be able to put this action to use in the way the Egyptians did? When they wanted to separate a large block of stone from the native rock they cut a groove to mark the outlines. Into this groove holes were drilled, and into the holes wooden wedges were tightly driven. When the wedges had been inserted the groove was filled with water. Surrounding the wedges, it was soaked up by the wood. The wedges swelled, irresistibly, until their combined force cracked the rock asunder and split it the length of the groove!

Then the real work started. To get this massive, unwieldy block to its destination was not just a simple matter of placing it on a freight car. They made rollers, from the branches of palm trees, on which to push the stone to the Nile. Seeing a gang of stevedores handling a heavy, oversized crate will give one some idea of the job it must have been. Hundreds of men, pushing, straining, panting, edged along the great mass inch by inch, with the hot, dry dust billowing up from the ground and coating their parched throats. There were no unions in those days, and the overseers were adept with the whip. Whether or not this superhuman work was partly accomplished by offering the slaves their freedom if they transported a certain number of stones, is a matter for argument; but the fact remains that many of them kept a record by marking the stones they hauled or helped to haul. Marks of this description are still to be seen on some of them.

Finally, with a stone resting on the river bank, out came the axes, and down fell the hundreds of trees that were required to build a raft around the stone. It must have taken hundreds of feet of timber to float those huge blocks. And when the waters of the Nile rose, the raft was set adrift and carried its tremendous burden to the point on the stream nearest the spot where the obelisk was to be set up. "Thousands of laborers then dragged and pushed the stone on rollers up an inclined plane where, by the use of levers and ropes made of the date palm, the obelisk was placed in its final upright position."

It is pleasant to read, also, that the men in charge of these great enterprises were not without honor in their own land. From the ancient engineers were drawn "the adviser of the king, his ministers and his generals, and each usually held a sacred office in addition to his secular duties. His burial was solemnized with pomp and display, and statues and other monuments were erected to perpetuate his memory. M. de Sarzec found a statue of Telio, from the earliest period of Chaldean art (about 400 B.C.) which holds upon its knees a tablet upon which the plan of a fortress, with its bastions and posterns, is engraved in outline, just as an architect of the present day would draw it. A graduated rule—that is to say, one subdivided into fractions of unequal but proportional length, 10¾ inches long—is carved in relief beside the plan, for which it serves as a scale. Finally, at the side lies the style with which the architect engraved his design." As far back as 3700 B.C., Egypt had its "Superintendent of Works," who was in charge of the construction and repair of all public buildings and projects.

It is only a brief step from a cursory study of the ancient engineering methods to a further investigation of the sources of supply from whence came all the stone for the magnificent edifices. In *Travels in the Upper Egyptian Deserts,* a fascinating book by Arthur E. P. Weigall, Chief Inspector of Upper Egypt; Department of Antiquities, are found pages rich in information. Mr. Weigall's many expeditions led him far into the deserts. He visited quarries that had been worked as distantly as 2400 B.C.—quarries which, for the most part, had been unvisited by humans for 2,000 years!

In the Wady Hammamat quarries are huge blocks of tuff that had been prepared for shipment. Silently they have remained there, waiting, year in and year out, doing nothing more useful than casting a small shadow as the sun moves overhead. And

many of them are addressed to long dead Caesars! What exciting story do they hold? Why were they never delivered? Perhaps in distant Rome—far from the ringing hammers of the stonemasons—a throne toppled. And there were no telephones to tell the quarrymen. Then there are numerous messages and inscriptions carved in the rock. Sometimes just names—probably chiseled during a restless noonhour.

A quarrying expedition in those ancient days was no simple matter. It took weeks of preparation, organizing ability at which it is not difficult to marvel, and hundreds of men. A record is given of one that was undertaken in the year 1165 B.C. The reigning Pharaoh was an energetic fellow, and after making a trip to the quarries and selecting the stone that he desired he sent out an expedition, which Mr. Weigall describes as follows:

"The head of the expedition was none other than the High Priest of Amon, and his immediate staff consisted of the king's butlers, the deputy of the army and his secretaries, the overseer of the treasury, two directors of the quarry service, the court charioteer, and the clerk of the army lists. Twenty clerks of the army, or of the War Office as we would say, and twenty inspectors of the court stables were attached to the group. Under a military commandant there were 20 infantry officers and 5,000 men, 50 charioteers, 200 sailors, and a mixed body of 50 priests, scribes, overseers, and veterinary inspectors. Under a chief artificer and three master quarrymen there were 300 stone-cutters and quarrymen, while the main work was done by 2,000 crown slaves and 800 foreign captives. Two draughtsmen and four sculptors were employed for engraving the inscriptions, etc. A civil magistrate with 50 police kept order amongst his large force, which altogether totalled 8,362 men, not including, as the inscription grimly states, the 900 souls who perished from fatigue, hunger, disease, or exposure." And all these men had to be fed—out in the barren desert wastes. One does not envy the head of the commissary!

When Imperial Rome was at the height of her glory, there was a magnificent purple stone known as Imperial Porphyry that was greatly prized for ornamental purposes. This stone was too expensive for use by any but the rulers of the earth, and they obtained it only by the sweating toil of their subjects. The quarries were situated ". . . .in the region known as Gebel Dukhan, the Hills of Smoke, in the Eastern Egyptian Desert, some 27 miles from the Red Sea, opposite the southern end of the Peninsula of Sinai."

It was in this quarry that Mr. Weigall records the presence of a proud granite altar, set in a temple, which has stood serenely through the centuries, bearing the awe-inspiring inscription: "For the safety and the eternal victory of our Lord Caesar Trajan Hadrian, absolute, august, and all his house; to the Sun, the great Serapis, and to the co-enshrined gods, this temple, and all that is in it, is dedicated." It was at this altar that the quarrymen and the Roman officers living far from their homes and families—worshipped their gods and the rulers who had sent them to this outpost of the Roman Empire. Although the quarry was in Egypt, the Egyptians did not know of its existence. Imagination suggests many possible adventurous explanations—but perhaps we'd better stick to facts.

The ruins of a town still stand near the Imperial Porphyry quarries. Besides the ordinary houses there is a large building which investigation has proved to be a plunge bath. Here the officers would gather after the toil of the day to relax in the cooling waters and to discuss probably the same things that isolated people discuss today—home, mutual friends, the government. "The town is, of course, very ruined," to quote Mr. Weigall, "but it does not take much imagination to people it again with that noisy crowd of Greek, Roman, and Egyptian quarrymen. One sees them prising the blocks of purple porphyry from the hillside far above the valley, returning in the evening down the broad causeway to the town, or passing up the steps to the temple which stands on a knoll of granite rocks a couple of hundred yards to the northeast."

Strangely enough, the quarries were not cut with any great regularity. Wherever seemed a promising place to get a large block from the hillside, there the men went to work. This haphazard method of extracting the stone bespeaks an almost unlimited supply. As the rock had a long and difficult journey to Rome, "over parched deserts and perilous seas," there was not much done on it at the quarries. It did not even receive a preliminary dressing, and was sent out in the rough state.

The Byzantine emperors also were very partial to the purple stone and carried on the work of their Roman predecessors until the fifth century A.D. There is no other place in the world—as yet known—where this beautiful rock is to be found; and "when the quarries at last ceased to be worked, sometime previous to the seventh century, the use of that stone had to cease also, nor has it ever again been procurable." It is interesting to learn that in 1887 a Mr. Brindley obtained a concession to operate the quarries. Unfortunately, however, his scheme did not prosper—mostly because of the difficulties of transportation—and he had to abandon his project.

Another very popular stone during the Imperial Age was a fine white granite speckled with black. It was employed extensively for building purposes—in fact more so than the Imperial Porphyry. Like the latter it was unknown to the Egyptians, who would doubtless have made exceptionally attractive things of it had they been aware of its existence. This beautiful stone was found in the quarries of Mons Claudianus. The settlement that grew up around them was also called Mons Claudianus, but as the well that supplied it with water was known as Fons Trajanus, in honor of the Emperor Trajan, some people called the town by that name.

The blocks sent to Rome from this quarry were frequently of a truly amazing size, "often of dimensions which one would have regarded as prohibitive to transportation." And because they had a difficult journey ahead of them, and were so large and heavy, they were dressed at the quarry to within an inch or two of their ultimate size. This necessitated a reasonably large town to house all the workers; and Mons Claudianus was probably the largest quarrying center of its time. Skilled masons had to live there so as to be on hand for dressing the stone. Quarrymen, of course; and engineers camped right on the ground. And no doubt the architects made occasional visits to see how things were going, or perhaps to specify blocks of certain dimensions for important jobs.

Mons Claudianus was built on a more permanent basis than were the other communities; and the bath house is still complete enough to be interesting to this day and age. It will be noted in the following description that central heating—or a variation of it—was in use. Central heating, as we know it today, is comparatively new. Yet it seems that "progress" has eventually brought us back to a method practised by the Romans centuries ago. "One first enters a good-sized hall in which three small granite tanks stand. Here the bathers no doubt washed themselves before entering the baths proper. From this silent hall two doorways open. The first of these leads into a series of three small rooms which were heated by furnaces in the manner of a Turkish bath. These chambers seem to have been heated to different degrees, for under the floor of the innermost is a large cavity or cellar for the hot air, whereas in the other rooms there are only pottery flues, which pass down the walls behind the plaster."

There is something about the ancient inscriptions that never fails to fascinate. They have a majesty, an impressiveness, that modern ones seem to miss. Probably because we do not take our exalted personages so seriously as did the ancients. In the temple of Mons Claudianus is the usual altar, with this inscription: "In the twelfth year of the Emperor Nerva Trajan Caesar Augustus Germanicus Dacicus; by Sulpicius Simius, Prefect of Egypt, this altar was made." There may be nothing in a name, but if you can stretch it out enough it begins to sound like something.

And again we find at this quarry "several huge columns, already trimmed, and many smaller blocks left in the rough. Most of these are numbered or otherwised marked, and on one enormous block, hewn into the form of a capital, there is written: 'The property of Caesar Nerva Trajan.'" Perhaps some day it will be claimed.

Meanwhile, for more centuries, the old quarries may lie idle. Or, will they once again echo the shouts of workers, this time with the rhythmic clatter of air drills, the hum of modern machinery?

# It Pays to Reclaim Grease

*A. M. Hoffmann*

**INITIAL STAGES OF THE WORK**

**As the grease cakes arrive they are cut out of their screens (top, right) and given a lye bath (left), after which those that are fit for re-use are reshaped in the pneumatic press shown directly above.**

IN THE Columbus, Ohio, shops of the Pennsylvania Railroad is a section that is given over to the reclamation of grease used in the lubrication of its locomotives. Since its establishment, this department has paid for itself over and over again, thus proving its practicability as well as that of the equipment in service there. This has been especially designed for the work and is, for the most part, operated with compressed air.

Only the grease from the locomotive driving-box cellars is salvaged. It is in the form of cakes, which are pressed into screens to keep them in shape. On arriving from various points along the system, the lubricant is cut out of its holders and assorted—that which is too dirty and worn being thrown away while that which is clean is again made into cakes and plugs of prescribed dimensions to fit the screens as well as grease cups on side and main rods and elsewhere on a locomotive. The screens also are reclaimed if their condition is such as to warrant it.

The screens are thoroughly cleaned by boiling for from 30 to 60 minutes in a lye solution and by washing with a hose to remove the caustic and any remaining dirt. After that they are heated in a small furnace preparatory to reshaping in a pneumatic press consisting of a vertical and two horizontal cylinders. Air is first admitted to the upright cylinder, which forces down the top die and gives the screen the correct curvature, and then to the horizontal ones to push the pistons with their flat platens against the sides, thus straightening them. Following cooling, the screens are given a bath in cold water and are then ready to receive the grease cakes which are made from reclaimed and new stock.

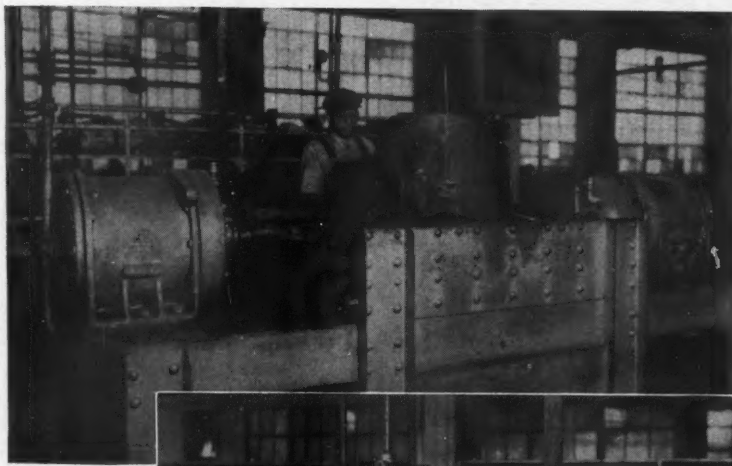
The new supply reaches the plant in a solid mass, and to facilitate handling is cut up into small pieces by a machine built of heavy channel iron. Mounted horizontally on each end of it is an 18x13-inch air cylinder to the piston rod of which is attached a steel knife 43 inches wide. This blade is disposed horizontally and travels in guides on each side of it. To it are welded in an upright position 6-inch-long knives—three in one case and two in the other spaced so as to interlock.

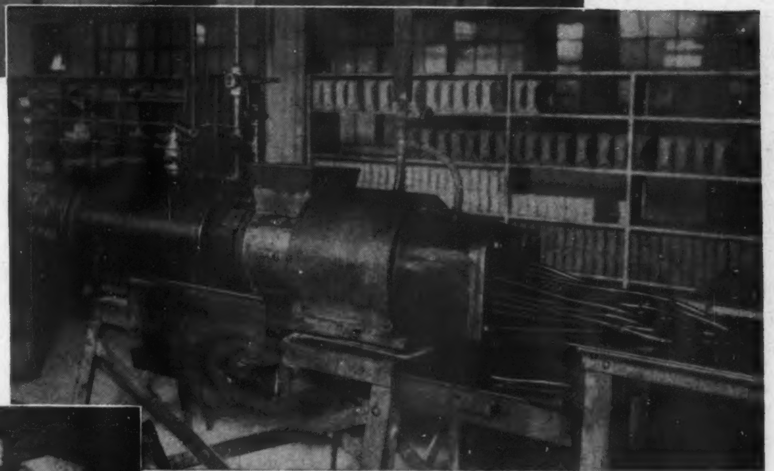
Just as it comes out of the barrel the grease is placed over an opening in the middle of the machine. With the turn of a valve, compressed air is simultaneously admitted to both cylinders, pushing the blades together slowly and cutting the lower end of the mass into small pieces that fall into a box set beneath it. The operation is repeated until the whole chunk has been cut up. This, it is said, takes but from two to three minutes.

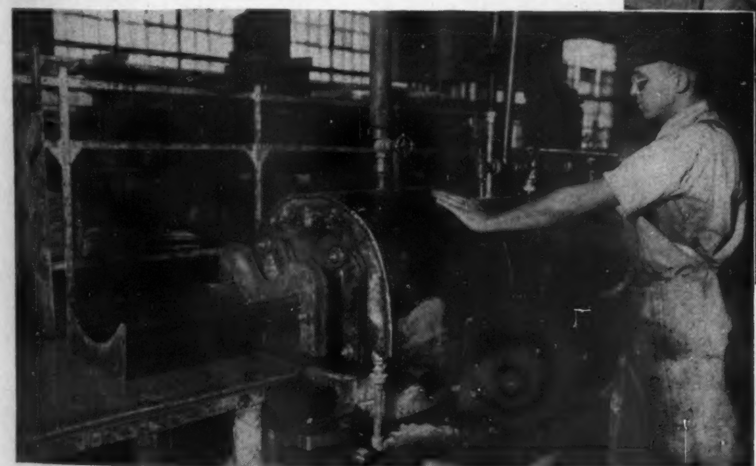
From the cutting table the grease goes to presses which give it the necessary shape. These operate on the same principle as the machines already described. The pieces are dumped into a hopper whence they are forced by a pneumatic piston first through a steam-heated chamber and then, in compact form, through a die bolted to

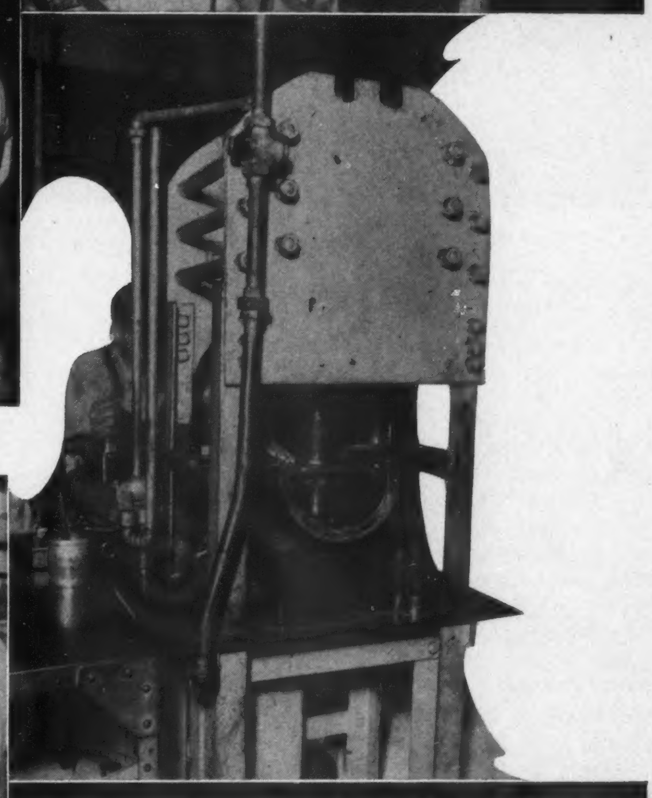
the discharge end of it. Two presses do all the work, the dies being changed to meet requirements by simply loosening and tightening a few nuts. The plugs are turned out in continuous rods, and as they issue from the machine are cut into 9½-inch lengths suitable for packing into boxes for shipment. As many as 44 of these rods can be produced at one time.

The screens have in the meantime been cleaned and reshaped and are in condition to receive a fresh supply of grease. Each is slipped down over a cake and locked in a boxlike frame that is hinged at one corner and arranged to be opened at the opposite corner—strap bolts serving to hold it shut. This frame is spotted beneath the plunger of a press, the forming punch is swabbed with water, and the screen is coated with oil in preparation for the final operation, which consists of applying pressure until the grease comes through the holes in the screen. Wrapped in heavy paper the cakes are put in stock ready when needed for their work of lubrication in the driving-box cellars of the Pennsylvania's freight- and passenger-train locomotives.









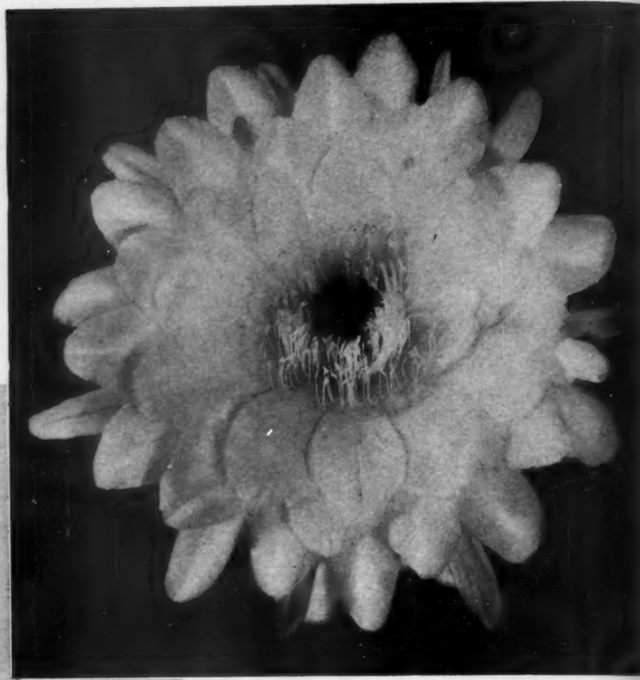
Photos courtesy Modern Machine Shop

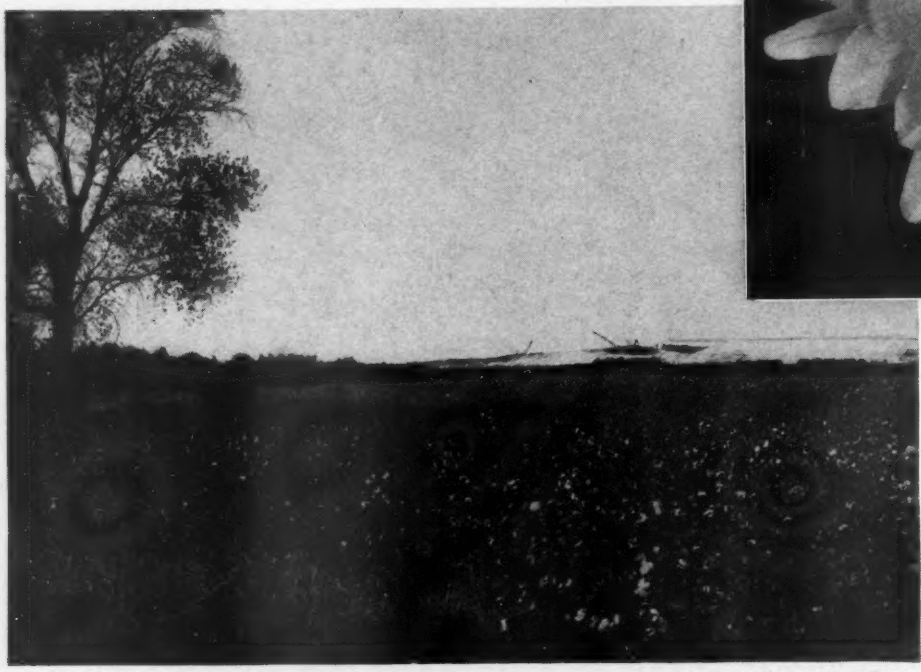
CUTTING AND PRESSING OPERATIONS

**Following the work in its proper sequence, the pictures, from top to bottom, show the ingenious machine that cuts up a barrelful of new grease in from two to three minutes; the two forming presses, with their adjustable dies, from one of which is seen issuing numerous rods and from the other a cake; the metal frame in which each grease cake in its screen is locked; and the machine that applies pressure to the cake so encased until the grease comes through the holes in the screen. All the equipment is air operated.**

# Water to Make the Desert Bloom

Joseph C. Coyle





Bureau of Reclamation Photo

**DESERT VEGETATION**

**Where water has been provided the desert is in full bloom. Above is a field of cotton in the present irrigated area, with draglines at work in the distance on the new canal. At the right is pictured one of the fragrant white flowers of the night-blooming Cereus, a well-known cactus that is found along the international border.**

ALONG the southeastern border of California there is taking form 80 miles of man-made river with a maximum width at the surface of 232 feet. It is the All-American Canal, one of the three construction features of the Boulder Canyon Project authorized by the Act of 1928. The two others are the Boulder Dam and its associate power plant. Each is a part of the underlying plan for the control and economic use of the water of the Colorado River.

The ultimate canal scheme includes a diversion dam on the river, an 80-mile main canal to Imperial Valley, and a 130-mile main canal to Coachella Valley. Only the first two are included in the current program. The dam, to be known as Imperial Dam, is being built 20 miles upstream from Yuma, Ariz., and 5 miles above the existing Laguna Dam that diverts water to the Yuma Irrigation District in Arizona. Imperial Dam will serve also to divert water to the Gila Valley Canal, in Arizona, on which work has been started. Irrigation of 1,000,000 acres under the All-American system and about half that area under the Gila Valley system will eventually be made possible. The cost of the Imperial Valley section of the All-American Canal, not to exceed $38,500,000, will be repaid without interest by the farmers of the valley over a period of 40 years under a contract with the Government. There will be no charge for the use, storage, or delivery of water for irrigation or for potable purposes.

To appreciate fully the importance of these works, certain climatic and geological characteristics of the region must be known. Above the diversion dam is rugged terrain, unsuitable for cultivation. Starting 5 miles downstream, at Laguna Diversion Dam, lowlands on both sides of the river are now being irrigated, some from gravity-flow ditches and some from pumping plants. On the Arizona side of the river much of this land lies on a level mesa that extends southward into Mexico. It includes citrus farms that are noted for the high quality of their grapefruit. On the California side, a mesa that starts near Pilot Knob slopes westward and northward down to the Imperial and Coachella valleys at sea level. These valleys occupy an immense basin whose bottom is 280 feet below sea level.

In some past geologic age this basin was a part of the Gulf of California, which then extended northward past the site of the present City of Indio, Calif. An old shore line, well defined in places, a myriad of shells, and other evidence corroborate this. The Colorado River, carrying millions of tons of silt each year, gradually built its delta across this body of water, then turned southward, making an inland lake of the northern portion. Through the succeeding ages this lake gradually dried up, leaving the saucerlike depression. Meanwhile, the Colorado River has been flowing along its eastern rim, gradually building up its bed by the deposition of silt. Its elevation is approximately 100 feet above sea level, or from 100 to 350 feet higher than the land in the nearby basin. This condition constituted a grave danger during flood seasons, and to end it was one of the paramount reasons for the construction of the Boulder Dam.

The basin area extends southward across the international boundary into Mexico and to a flat delta, some 35 feet above sea level, that was built up by the Colorado River. As far back as 1858 it was recognized that the fertility of this basin made it a potentially rich agricultural region if it could be provided with water. The climate is similar to that of the Nile Valley, and the growing season is 365 days in a year. However, the annual precipitation averages only about 3 inches, an insignificant amount.

In 1900, a coöperative scheme was launched for the construction of a canal, and during succeeding years it was put through. To avoid the then dreaded sand-dune area north of the international boundary, and to cut down rock excavation to a minimum,

Bureau of Reclamation Photo

**SECTION OF COMPLETED CANAL**

This will be the largest irrigation canal ever built. Near the head it will be 160 feet wide at the bottom and 232 feet at the surface of the water, which will be 21 feet deep. There are two larger canals in the United States, both used for shipping.

40 miles of that canal, which is known as the Imperial, was routed through Mexico. To make this possible, a concession was obtained from the Mexican government, the stipulation being that Mexican farmers should have the right to use a certain percentage of all the water in the canal. Continually increasing development of lands in Mexico, together with periodical shortages of water in the Colorado River during low-flow stages, has made drought an ever-growing menace in the Imperial Valley. The fact that the All-American Canal will be located entirely on United States soil will remove one of these sources of apprehension, while the building of Boulder Dam, with its huge storage reservoir, has already put an end to the other.

The Imperial Canal takes water out of the Colorado a short distance below Yuma, Ariz. In the summer of 1905 the flow of the river became very low, and in an effort to divert more water into the canal a breach was made in the levee that had been built to keep the stream in its elevated channel. A sudden flood enlarged this gap, with the result that the entire river was soon flowing, out of control, into the Imperial Valley. Many trainloads of rock were hauled from points up to 400 miles away to close the opening, which was finally done in 1907 at a cumulative cost of $4,000,000. Meanwhile, a lake 515 square miles in area had been created in the bottom of the basin. This Salton Sea, as it is called, has since partly evaporated, but it still covers about 287 square miles and has a maximum depth of 30 feet. Its surface elevation is now about stable—250 feet below sea level.

The portion of the basin that lies south of the Salton Sea is known as the Imperial Valley, while that north of it is named Coachella Valley. At present Colorado River water does not reach the latter, but between 400,000 and 450,000 acres in Imperial Valley are ditched and under cultivation. The principal crops are alfalfa, cantaloupes, lettuce, barley, corn, cotton, silo maize, and small fruits. Because of the perennial growing season, yields are great. From 7 to 10 tons of alfalfa can be obtained per acre—a ton to the cutting; and a single acre will produce around 95 crates of cantaloupes. About 30,000 carloads of cantaloupes and lettuce are shipped out each year.

The total irrigable area in Imperial Valley has been placed at 522,000 acres, the watering of which will require approximately 1,700 miles of canals and laterals. Coachella Valley has an area of 187,000 acres, of which 150,000 acres will be under the new canal system. About 16,000 acres are now being irrigated by pumping water from wells. Some artesian water also is available —the flow from one of these wells being sufficient to run a small ice plant and to provide a small amount of electricity for lighting purposes. Dates is a staple crop, as the climatic conditions in the valley closely approximate those of their native land, Arabia. Additional irrigable land to make up the 1,000,000 acres to be benefited by the canals is situated in the East Mesa, West Mesa, Pilot Knob Mesa, and Dos Palmos region. As already stated, only the main All-American Canal is now being built. The Coachella branch will be constructed later under a separate agreement.

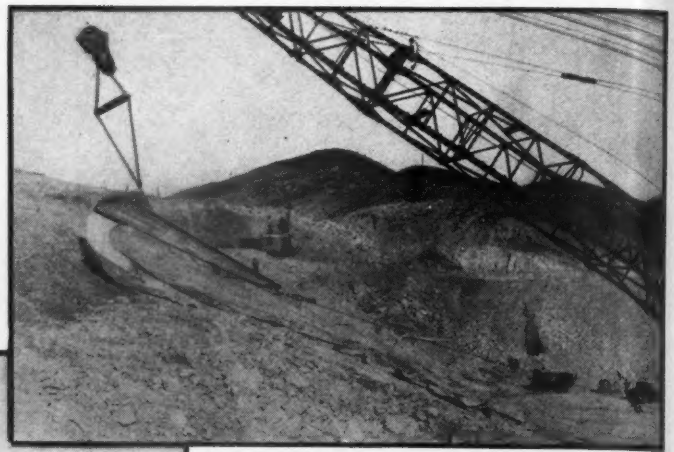
The country to be traversed by the canal to the Imperial Valley is such that power can be generated at five points, the total potential capacity being estimated at 60,000 kw. No generating equipment will be installed now, but substructures for power houses will be built concurrently with the canal at four of the five drops, all located between 40 and 64 miles from the intake. This was decided upon last summer after the U.S. Bureau of Reclamation engineers had figured that this procedure would save around $465,000. The cost of the substructures will be about $1,075,000. The four drops will provide heads ranging from 24 to 51 feet and aggregating 127 feet. The Imperial Irrigation District expects eventually to install the generating equipment and to operate the power houses.

The region is typically desert in character and, save for three or four rock cuts, the route follows generally sandy ground. In a 10-mile stretch of sand dunes a short distance west of Yuma it will be necessary to make several cuts up to 100 feet in depth. According to preliminary estimates by Government engineers, of the total 60,000,000 to 65,000,000 cubic yards to be excavated in carrying the canals to Imperial and Coachella valleys only 4 per cent will be rock. Two rivers, the Alamo and the New, as well as numerous dry stream beds or washes must be crossed. In some cases this will require the construction of siphons or culverts.

Excavating being the principal work in the building of the canal, contractors recognized from the first the need of modern equipment capable of moving large quantities of material and of doing it fast. Much of the upper 35 miles, from the diversion dam to beyond the sand dunes, constituted common excavation. However, it was broken by the dunes, by rocky elevations, and

## A "ROOTER" AT WORK

At Pilot Knob have been encountered extensive deposits of cemented gravel. To break it up, a 10-ton spiked tool is swung from a dragline boom, as shown at the right. The point is plunged into the formation by dropping it, and is then drawn down the bank to loosen the material. Where the gravel is too obstinate to be excavated in this manner it is drilled and blasted. Below, in what might be termed the Sahara of America, cuts up to 100 feet deep are required to reach grade. At the right is a 10-W walking dragline, and at the left a 6-W unit of the same type, both traveling down the canal line making the inital excavation. They are handling the light blow sand which is covered with a heavier sand found at a lower level to prevent it from being carried back into the canal.



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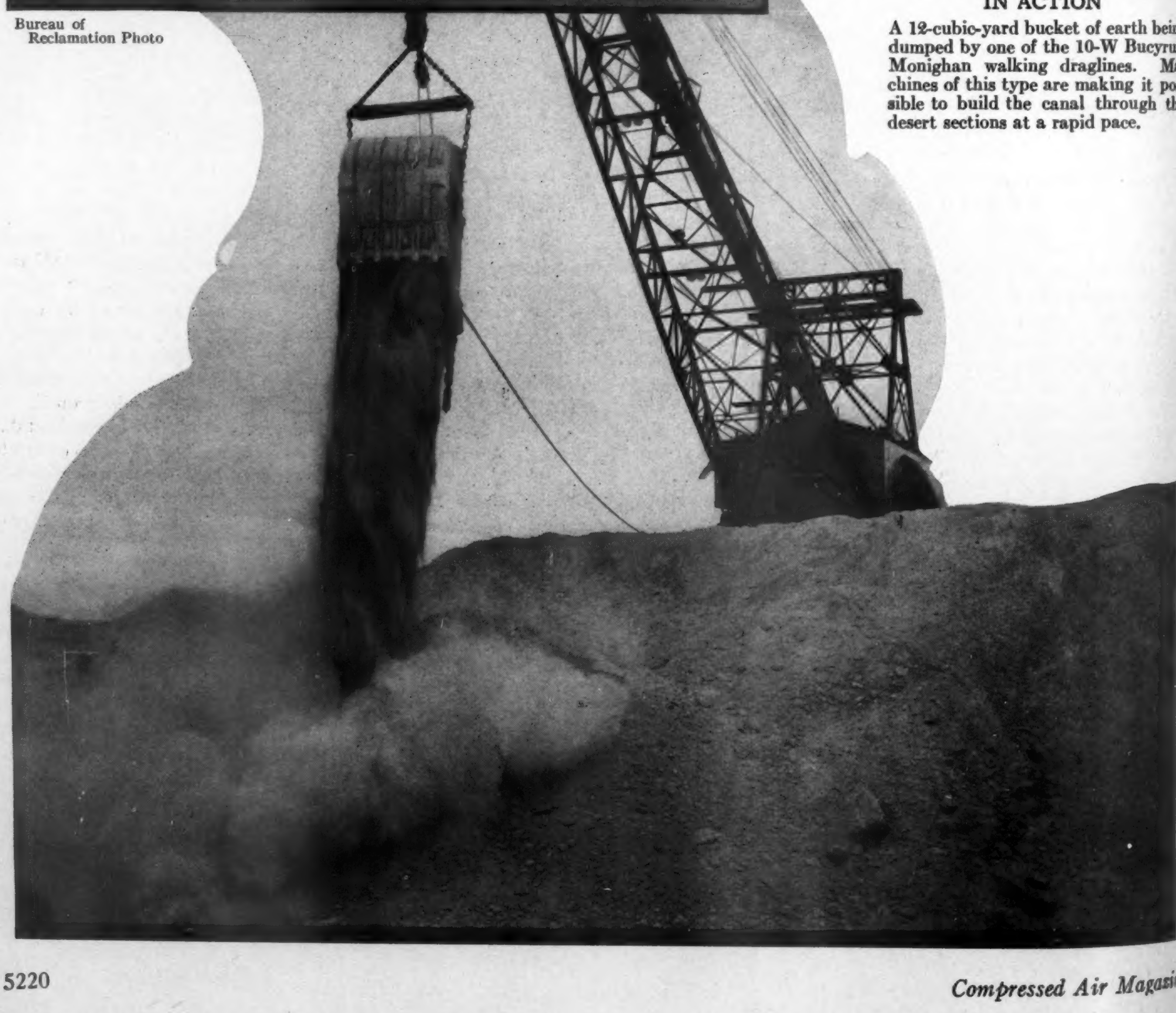


## A MECHANICAL GOLIATH IN ACTION

A 12-cubic-yard bucket of earth being dumped by one of the 10-W Bucyrus-Monighan walking draglines. Machines of this type are making it possible to build the canal through the desert sections at a rapid pace.

by innumerable desert washes that were normally dry but at times became torrential streams. Rocky ridges separated many of these channels. These obstacles, which had made a canal along this line impossible in the days of hand drilling and team-drawn scrapers, present no great difficulties now because of the availability of air-operated drills, powerful bulldozers, and monster draglines having buckets that are 12, 14, and sometimes even 16 cubic yards in capacity.

An index of the truly gigantic proportions of some of the equipment on the job is had in the fact that more than 100 freight cars were needed to transport the machines used by one group of contractors to excavate a 30-mile section of the canal. Outstanding among these mechanical titans are the Bucyrus-Monighan draglines. The largest of these—the 10-W, of which several are in service—weigh 650 tons each and required 20 freight cars for their delivery. The boom is 175 feet long and is rigged with 3,300 feet of 1¼-inch line. When loaded, a 12-cubic-yard bucket weighs 25 tons and is handled by a 2-inch drag cable. Under average working conditions, the machine can load a bucket, swing through 180°, dump, and return for another load in 90 seconds.

Known as a walking dragline, the huge machine travels 7 feet at a step with no perceptible effort or jar. Each walking platform or "shoe" weighs 42,100 pounds. Power for operation is derived from two diesel engines, one of 450 hp. and the other of 100 hp. In all, it has seventeen electric generators and motors. Of these the largest are two 100-hp. units that swing the machine on its 36-foot circular base, and the smallest is a ½-hp. unit that operates a centrifuge. The hoist is driven by a 36-inch belt from the 450-hp. diesel.

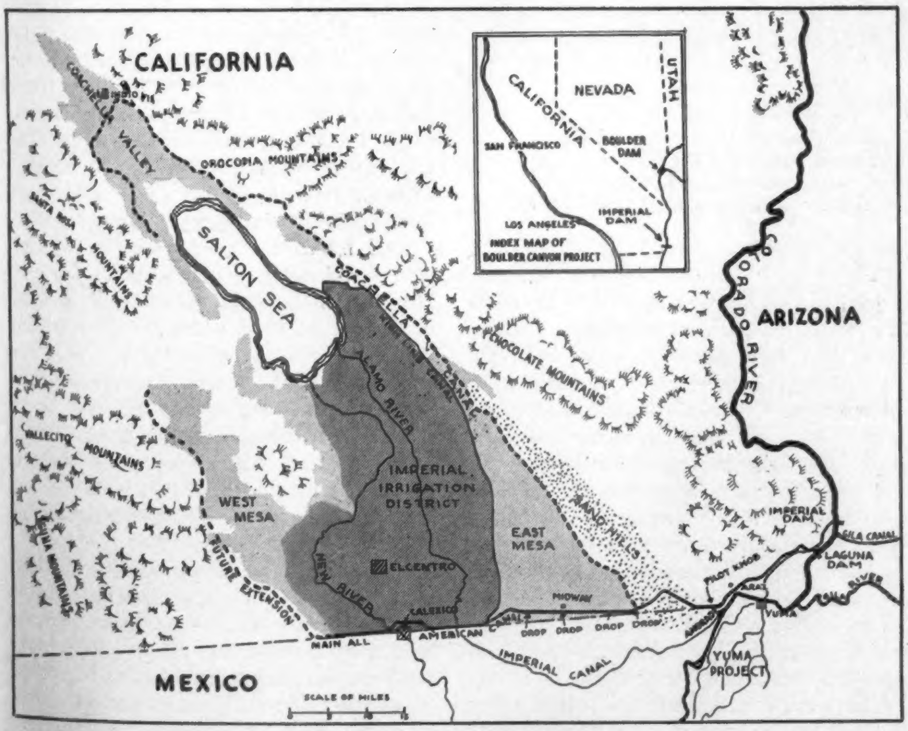
The first dragline of this type and size was built in 1930. Maj. L. D. Crawford, who was partly responsible for its design, is vice president of W. E. Callahan Construction Company and Gunther & Shirley which combination is digging the 30-mile stretch of canal previously referred to. In addition to the 10-W's, there are many smaller draglines, including Bucyrus-Monighan 6-W's. These weigh 275 tons each, have a boom from 100 to 125 feet long, and get their primary power from a 240-hp. diesel engine. In general, the big machines do the heavy excavating, and each is assisted by one or more of the smaller draglines that rehandle material, trim slopes, and help to construct roads. Other large equipment also is employed, notably tractor wagons that can haul 25 cubic yards at a load.

Near its head the canal will be 160 feet wide at the bottom and 232 feet at the surface of the water, which will be 21 feet deep. Its capacity will be 15,155 second feet. Where washes are encountered, material sometimes has to be borrowed to build

Bureau of Reclamation Photo

**ROCK CUT AT PILOT KNOB**

**One of the rougher sections of terrain, where the cuts will have a maximum top width of 250 feet and a depth as great as 115 feet. The picture was taken at blasting time.**




**LOCATION MAP**

**Imperial and Coachella valleys lie in Salton Sink, a huge depression that was once a part of the Gulf of California. Realizing the fertility of the soil, Oliver M. Wozencraft first proposed irrigating the area in 1857, but he was unable to finance the plan. Nearly a quarter of a century later Charles R. Rockwood, an irrigation engineer, became interested, and after ten years of endeavor secured backing for a gravity canal that was opened in 1901. That canal, the Imperial, flows for 40 miles through Mexico, a route that was dictated by the topography. It is now being supplanted by the All-American Canal, which will extend westward for 80 miles from the Imperial Dam on the Colorado River. The future extension of the canal and the projected Coachella Canal are indicated by dotted lines. At the lower right is shown the start of the Gila Valley Canal, for which water will also be diverted by Imperial Dam. The heavier shading indicates the area now under cultivation: the lighter that to be ditched when the canal system is completed.**

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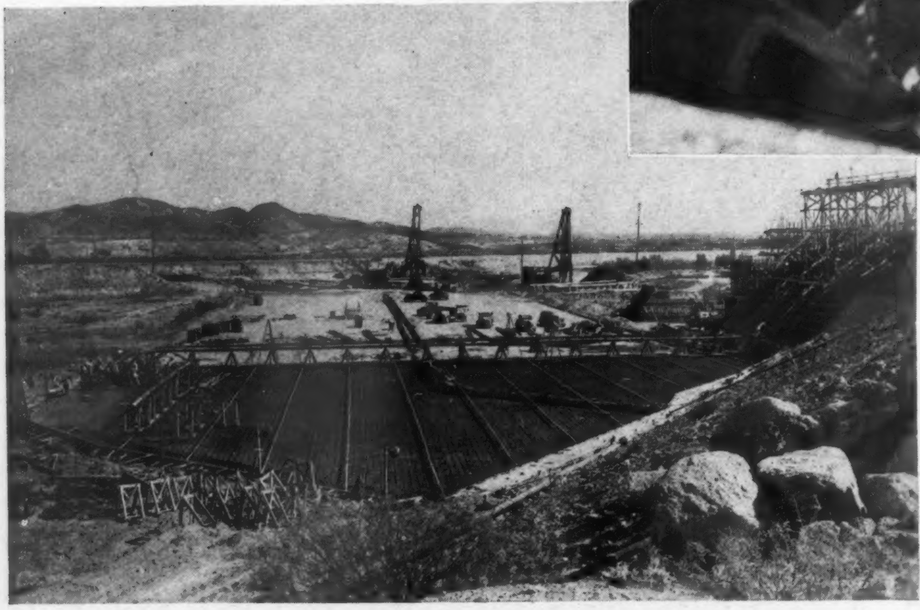

WORK AT IMPERIAL DAM

**On the California side and looking upstream from the dam. In the foreground is seen the partly poured concrete slab, and at the right the abutment of the dam in course of construction. The desilting basins and some of their connecting channels are to be lined with riprap. The upper picture shows Jackhamer men breaking quarried rock down to the proper size for this purpose.**

up the normal embankments, but ordinarily the spoil obtained is more than sufficient to form such structures. As a result, the banks are usually from 30 to 40 feet above the canal grade. A 20-foot berm is left on one side and a 24-foot roadway on the other. Surplus material is wasted outside the lines of these two border strips. Both size and capacity will be progressively reduced as water is removed along the route and the head thus lowered.

At Siphon Drop, about 20 miles from the intake, 2,000 second feet will be supplied to the Yuma Canal which now irrigates land on both sides of the river, crossing to the Arizona side in a siphon that was constructed by Government force account in 1911. Near Pilot Knob, about 7 miles west of Yuma, a 3,000-second-foot wasteway for emergency relief of the canal is to be constructed. West of the sand dunes the Coachella branch will later divert 2,500 second feet. The main canal will end near Calexico, after swinging around the town and crossing New River in a siphon. The final section will have a bottom width of 100 feet and a water depth of 13 feet.

Actual construction on the canal was started during the summer of 1934, when 10 miles of the route near Calexico was excavated by force account to provide relief work for local farmers who were hard hit by the extreme drought. Subsequently, 12 more miles were taken in hand under the same plan. Initially, teams, fresno scrapers, and farm tractors were used on the job, forming a decided contrast to the heavy mechanized equipment employed today by the contractors. Some of the work that was begun with relief labor is now being finished by the Peterson Construction Company, of Los Angeles, Calif., which firm is also building a short adjoining stretch.

The general procedure followed by the Bureau of Reclamation has been to let contracts by schedule, each covering a specific section of the canal. More than fifteen contractors and subcontractors are at present engaged on various phases of the construction. Last July, when work had been underway seventeen months, the bureau reported that 44½ miles of the canal had been excavated and that 34,994,900 cubic yards of earth and rock had been moved. At that time, the amount of digging done each day was equivalent to a hole deep enough to bury an 18-story building. Working through the sand-hill section near the Colorado River, where heavy cuts are frequent, the Callahan and Gunther & Shirley combination had removed 26,565,400 cubic yards of material. Since July excavating has been proceeding at an even faster pace, and within a few months will be substantially completed.

To give the reader a glimpse of the operations at various points, we will start at the upper end and go westward along the line. The 4-mile stretch from the desilting works to Laguna Dam was awarded to the George Pollock Company of Sacramento, Calif., on a bid of $700,987.70. This stretch includes a rock cut that is the largest on the project. About two-thirds of it has been excavated with the aid of wagon-mounted drills in the main section and smaller hand-held drills on the slopes. Broken rock is loaded by a Marion 2½-cubic-yard electric shovel and used to blanket the outside slope of a compacted fill at the east end of the cut. This fill was subcontracted to the Lewis Construction Company of Los Angeles; and the methods employed there will serve as an example of those in general use elsewhere for compacting embankments or canal lining where seepage is likely to occur. This fill is 8,200 feet long, 144 feet wide at the bottom, 27 feet wide at the top, and 26 feet high.

Sheet piling is driven under the fill line, 30 feet deep. Selected material from a borrow pit, 2 miles away, is wetted and loaded by a power shovel into 16½-cubic-yard trucks. These travel to and from the fill at speeds up to 35 miles an hour over a smooth road that is sprinkled and graded every day by the contractor. Outside traffic is barred. The trucks enter the fill over ramps from the canal bottom. The material they dump is spread with bulldozers to a thickness of 6 inches. Rock more than 5 inches in size is picked out, and the area compacted with sheep's-foot rollers. Sufficient moisture to meet the requirements is added from tank trucks. The inner slope is blanketed with 12 inches of selected gravel.

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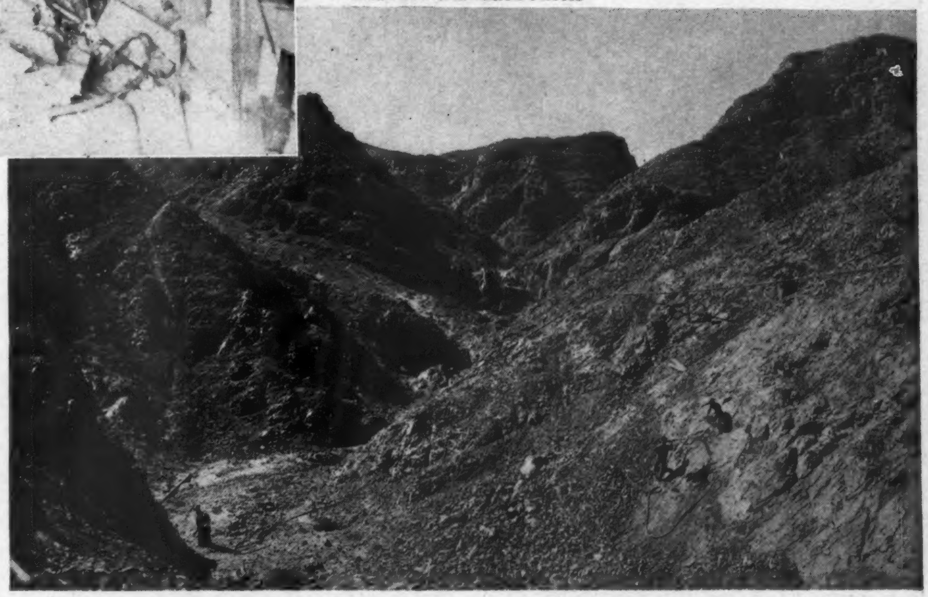


**ON THE GILA VALLEY PROJECT**

**Imperial Dam will divert water to the Gila Valley Canal as well as to the All-American system. Work is now underway on the first 17 miles of the former undertaking. It includes two tunnels, 1,740 feet and 4,124 feet long, respectively. These pictures show a drill rig at work in one of the headings and sealing operations in progress in the rugged open-cut section between the two bores.**

Other sections of the canal bank at points where excessive seepage is indicated are excavated back of the regular lines and are given a compacted lining by methods similar to those just described. Paved inlets lead into the canal at small washes to handle storm water, while overchutes of reinforced concrete are being built across the canal line at some of the larger washes. At four of the biggest of these the Frazier-Davis Company, of St. Louis, Mo., is constructing concrete siphons. In pouring the flaring, flattened ends of the transition walls, air-operated vibrators are used against the outside of the forms as well as in the concrete itself to consolidate it.

From Laguna westward to Pilot Knob, the work is in charge of the Callahan-Gunther & Shirley combination and its subcontractor, the Boyce-Igo Construction Company of Baton Rouge, La. In the sand-dune section, the depth of cut is so great that considerable rehandling of the material excavated by the 10-W draglines is necessary. This is done by the smaller draglines. The top sand is so light that it is easily carried away by the wind, and is therefore termed blow sand. Fortunately, heavy wash sand is found beneath this surficial deposit.

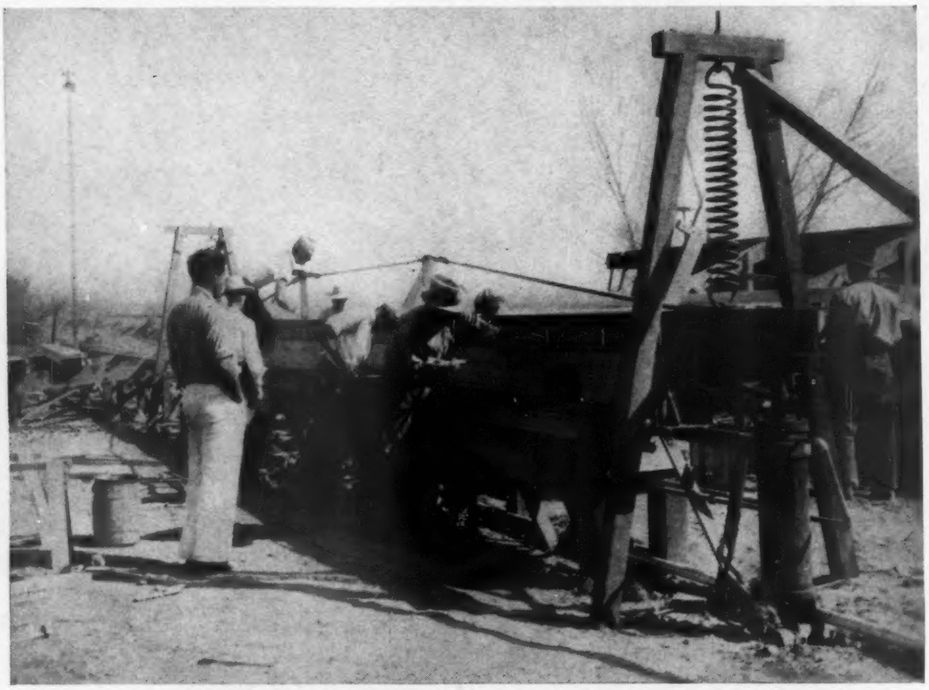
After the canal has been dug and the banks have been formed, this heavy sand is spread upon the blow sand at the edges, thereby preventing it from being carried back into the channel. The general procedure is to scoop off the blow sand with a 10-W, which then walks back and roughs out most of the channel inside the stakes marking the cut lines. It is followed by a 6-W dragline that finishes and slopes one side from the berm. A similar dragline slopes the opposite bank. Evidence that this region was not always desert has been found in the dune section in the form of teeth and leg bones from large prehistoric animals. These have been unearthed at depths of 30 to 40 feet below the mesa floor.

Both cemented gravel and hard rock were encountered near Pilot Knob by these contractors. The rock and in part the gravel were drilled and blasted, using R-39 Jackhamers that were supplied with air by two Ingersoll-Rand type portable compressors. Some of the gravel could be loosened with a 10-ton spiked tool termed a "rooter," which was swung from a dragline boom and drawn through the consolidated material. About 600,000 cubic yards of rock remains to be excavated near Laguna by the Callahan Company. This is being stripped as closely as possible with the draglines, after which a wagon drill and R-39 Jackhamers do the needful drilling.

At Pilot Knob, a rocky elevation, the Griffith Company of Los Angeles is making two cuts. The bottom width is 69 feet, the top width reaches 250 feet in places, and the maximum depth is 115 feet. Two wagon drills and a number of S-49 Jackhamers are in service there. This hill, which received its name from early navigators of the Colorado River, has several streaks of volcanic rock that range from 3 inches to 3 feet thick. These have proved so hard to drill that as many as 50 bits are sometimes required to put down a 2-foot hole. Wherever feasible, adjacent rock is first blasted to aid in breaking up this formation. The contract price for the job, including both rock and common excavation, is 42 cents per cubic yard.

Westward from Pilot Knob another section is being dug by the Callahan-Gunther & Shirley affiliation. Adjoining it is an 18-mile stretch in charge of the Lewis-Chambers Company of New Orleans, La. The latter is using three draglines, the largest having a 7-cubic-yard bucket. Abutting that contract on the west is a 7-mile section that was awarded to Mittry Brothers of Visalia, Calif., and subcontracted to the Callahan-Gunther & Shirley group. A 6-cubic-yard dragline, supplemented at times by a 2-cubic-yard machine, is being employed there.

Imperial Dam will be of the floating-weir type and 2,990 feet long, exclusive of a 470-foot rock fill on the Arizona end. The 1,200-foot center section will be a hollow weir of reinforced concrete having a maximum height of 31 feet. It will rest on the silt and sand of the river bed; will be partly filled with gravel as ballast; and will be strengthened inside by reinforced-concrete buttresses 2 feet thick. A gravel-filled drainage trench under it, provided with automatic ejectors, will serve to expel seepage water.



Bureau of Reclamation Photo

**MAKING TIMBER PILES**

**Tongue-and-groove wooden sheet piling for driving at Imperial Dam is formed by joining three sections together, as shown here. The timbers are placed on edge in a bench clamp and firmly held by an I-beam that is raised when desired by compressed-air pistons at either end. So secured, the timbers are nailed together, the 10-inch spikes used being started by hand and then driven with a riveting hammer.**

A reinforced-concrete apron will extend 65 feet downstream, and a pavement of 3- to 6-foot bowlders 150 feet beyond that.

On the Arizona side a maximum of 6,000 second feet of water will be diverted to desilting basins at the head of the Gila gravity canal through three gate structures separated by short nonoverflow sections. Diversion to each basin will be by nine radial gates. On the California side four roller gates, 75 feet long and 23 feet high, will regulate diversion into the desilting works for the All-American Canal. Between the latter gates and the overflow weir twelve radial gates will admit water to a sluiceway, reaching 3,000 feet downstream, which will carry off the silt removed by the plant.

The excavation for the California abutment, which has been poured, was carried down 50 feet to solid rock. The gate structures now being built on each side of the river will rest on about 2,500 eight-ton reinforced-concrete piles 50 feet long. Whenever possible these were driven almost full length, otherwise to refusal. Projecting ends of the piling were chipped off with CC-45 paving breakers and the reinforcing bars cut off, leaving 9 inches to tie in with the reinforcing rods of the horizontal slab of the surmounting structure. Concrete is pumped through 8-inch pipes and is placed by means of metal chutes, using air vibrators freely to consolidate the mass. It is mixed in a 60-yard-per-hour Pumpcrete mixing plant near the California abutment and in a similar plant of 30-yard capacity on the Arizona shore. Concrete is hauled to the desilting plant for clarifier pedestals, sludge-pipe galleries, etc. Backfills and embankments close to structures or sheet piling are tamped with Ingersoll-Rand tampers. Air is piped from an Imperial Type 10 compressor in the general contractor's shop.

The well-point system, with about 2,000 points and 40 pumps of various makes, is employed to remove the enormous amount of ground water inside the embankments and the cofferdams erected around the construction areas on both sides of the river. A great deal of sheet piling, both steel and wood, is being driven to cut off seepage. There will be three rows under a concrete paving slab that will extend 212 feet upstream from the dam, and another row in line with the downstream edge of the spillway apron. Embankments of desilting basins and channels, as well as a part of the canal, will be protected in the same way.

The wood piling is made by spiking together three timbers to form tongue-and-groove joints. Common practice has been to start the 10-inch nails with a hand hammer and to drive them through with pneumatic riveting hammers having heads adapted to fit the nails. This method has been further improved upon by placing the timbers on edge in a bench clamp and by holding them with an I-beam attached to the plungers of two improvised compressed-air cylinders below it and to large coiled springs above it, thus raising the beam clear as air pressure is released.

It has been estimated that the desilting plant at the head of the All-American Canal will save Imperial Valley $1,000,000 a year in dredging costs by removing 78 per cent of the tremendous volume of silt suspended in the waters of the Colorado River. It is by far the largest desilting plant ever constructed. Water from the intake will reach the six desilting basins through three influent channels separated by sheet piling, while a fourth channel will by-pass water to the outlet. Each basin will be 268 feet wide, 769 feet long, and 14 feet deep. Twelve mechanical clarifiers, each 125 feet across and rotating around its pedestal four times an hour, will scrape the silt that accumulates at the bottom of a basin into sludge pipes leading through concrete galleries to the sluiceway previously mentioned. The scraper arms of the clarifiers will move up or down automatically as the load increases or decreases. The mechanical apparatus for the desilting basins will be supplied by the Dorr Company, which was awarded the contract on its low bid of $564,800.

The inside of the basins, as well as of the sluiceway and of other channels in the desilting plant, will be lined with riprap. For this purpose, 200,000 cubic yards of rock—including 36,000 cubic yards of selected 3- to 6-foot stones for riprapping below the spillway—is being quarried near the Arizona end of the dam by Stringfellow Brothers of Los Angeles. S-49 Jackhamers are used to do the drilling in the quarry, where about ¾ pound of explosives has been required for every cubic yard of material blasted.

The rock is hauled to a stoneyard nearby, where oversize pieces not selected for the spillway riprap are drilled with Jackhamers and split with steel wedges. The individual stones must be more than 12 inches but not too large to handle in placing. Air is piped to both quarry and yard from a Type 40 compressor. Rock is loaded by a 10-B Bucyrus-Erie crawler crane with 1½-yard steel skips.

The Morrison-Utah-Winston Company—an affiliation of Morrison-Knudsen, Boise, Idaho; the Utah Construction Company, Ogden, Utah; and Winston Brothers, of Minneapolis, Minn.—are general contractors for the dam and desilting works. The bid price was $4,374,240.60. The contract was awarded on December 13, 1935, with a time limit of 800 days specified for the completion of the work. The Government will supply steel sheet piling, reinforcement bars, roller and radial gates, and various other materials. Among the subcontractors are: George W. Condon Company, Omaha, Neb., all excavation and fills; Merritt-Chapman & Scott, San Pedro, Calif., driving all piling and manufacture of wood piling; and C. M. Hill, fabrication and erection of reinforcing steel.

Contracts for the first 17 miles of the Gila Valley gravity canal, with headworks at the Imperial Dam, were let by the Bureau of Reclamation last April. It will irrigate 150,000 acres of new land in the Gila River Valley and on the Yuma Mesa. The total cost, estimated at $20,000,000, is to be re-

paid without interest over a period of 40 years by the Gila Valley Irrigation District. It is expected that the canal will be extended later to develop additional lands, up to a total of 585,000 acres, suitable for the cultivation of all crops now grown in the Imperial and Yuma valleys. Much of this acreage is owned by the Government, and is to be opened for settlement later, a little at a time.

Only 11,000 acres in the Gila River Valley can be irrigated by gravity. Power from Boulder and Parker dams will be used for the necessary pumping to lands on the mesa. The canal will be 22 feet wide at the bottom and 76 feet at the surface of the water, which will be 13½ feet deep. It is being dug on an offset line, thus providing for an ultimate development of the project that calls for a canal 100 feet wide at the bottom, 180 feet at the top, and 19½ feet deep.

The Boyce-Igo Construction Company, contractors of the dirt excavation, have completed about 2 miles of the canal from a point near the dam. The right of way, through loose sand and desert vegetation, including mesquite and occasional clumps of giant saguaro cactus, is being cleared partly by hand with the aid of diesel-powered bulldozers to push out the larger trees. These also level steep banks ahead of the draglines.

A 3-T Monighan dragline, with a 5-cubic-yard bucket, roughs out the channel from just inside the cut stakes on the lower side, casting most of the dirt on that side. A bulldozer levels the bottom and berm; and the side slopes are finished by a 3-cubic-yard Northwest dragline and then smoothed with a drag made of steel plate and swung under the bucket. If additional weight is required to iron out a tough spot the bucket is lowered on the drag. The Boyce-Igo contract does not include any compacted lining nor a siphon under the Gila River. These are to be let later.

The present Gila Valley gravity canal necessitates the driving of two tunnels through the Laguna Mountains, one 1,740 feet long the other 4,124 feet linked by a short open section. These are being built by Mittry Brothers. They will be 20 feet inside the concrete lining, which will vary in thickness from 8 inches, wherever steel ribs are placed, to 16 inches where there is no steel. A rock cut in the open section and the approach to Tunnel No. 1 were drilled with two wagon drills, mounted on the rear of small tractors, and some S-49 Jackhamers. The cut included a storm-water spillway blasted through the lower bank. Excavated material was loaded with a Koehring shovel and was used to make a fill just west of the cut.

Some difficulty was experienced with caving in getting underground, and the arch section of the tunnel had to be driven ahead a few feet and wall plates and segments of 12x12 timbers set before the main section could be blasted out and posts placed under the wall plates. Once underground, six Ingersoll-Rand N-75 drifters, mounted on a drill carriage, were called into service and are drilling the face with from 6- to 12-foot rounds, according to the stability of the rock. Sixty to 65 holes are required per round, those in the arch section being fired last to avoid shattering the top. The latter is barred down after every blast by men working from the jumbo. The rock breaks into large blocks; which caused much trouble in mucking until the head of the Conway mucker was raised 13 inches by inserting blocks on each side. Compressed air is supplied to the drifters and also to Jackhamer crews in the canal approach to Tunnel No. 2 by a 750-cfm. unit.

All the work described is being directed from the Yuma office of the Bureau of Reclamation. Roy B. Williams is construction engineer. J. K. Rohrer is resident engineer for the Imperial Dam and the desilting works, with Don M. Forester as associate. Grant Bloodgood is resident engineer for the All-American Canal, and Paul A. Jones for the Gila Valley Canal. J. C. Thrailkill is chief clerk, and T. A. Clark is office engineer at Yuma.

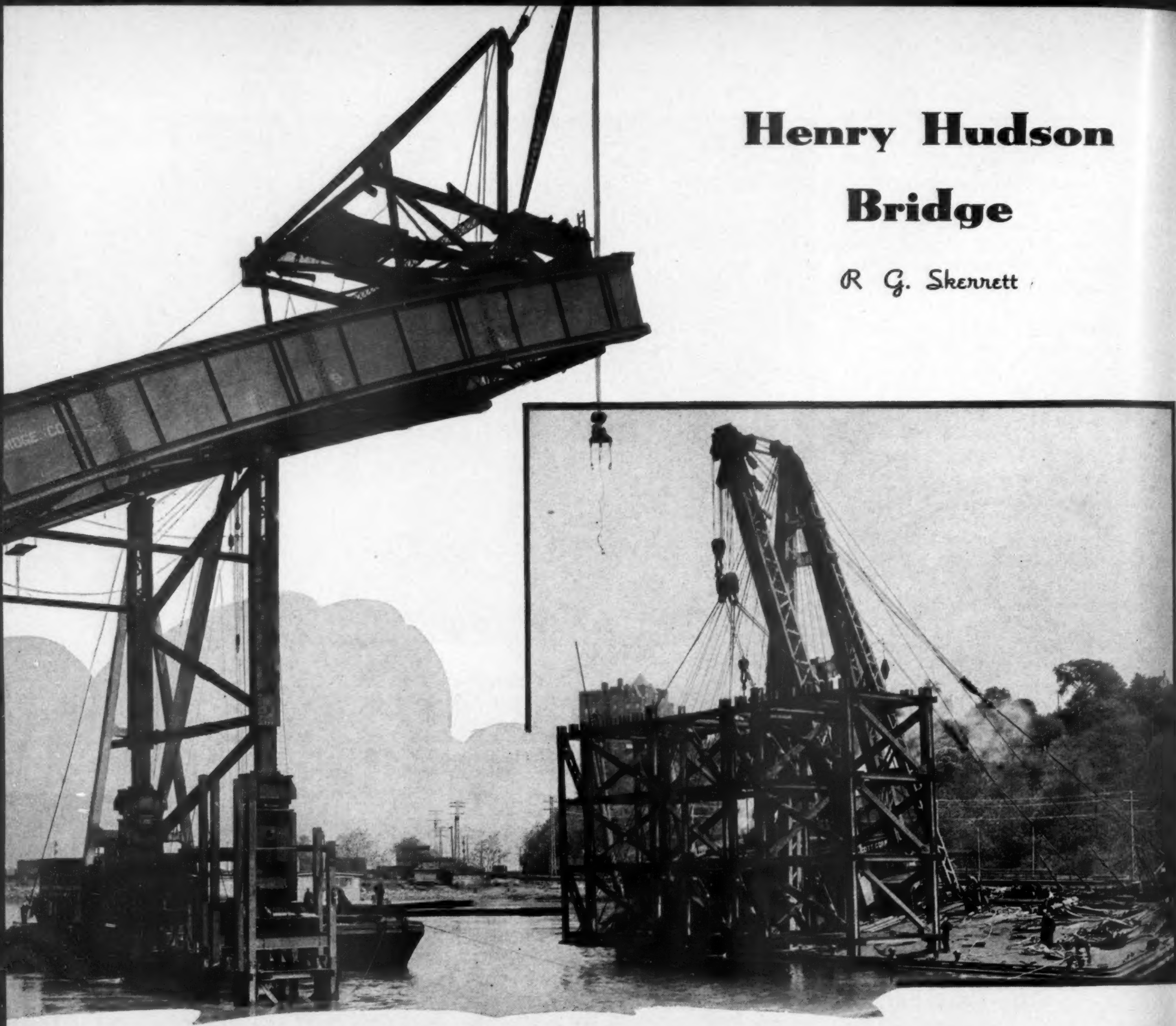
Bureau of Reclamation Photo

**CUTTING OFF PILES**

**The Imperial Dam gate structures on both sides of the river will rest on 2,500 eight-ton reinforced-concrete piles. These are 50 feet long and are driven to refusal. Projecting ends are then cut off at the desired level by chipping away the concrete with CC-45 paving breakers and burning through the bars with a torch, leaving 9 inches of steel reinforcing to which to tie the surmounting horizontal concrete slabs.**

**CONSOLIDATING FILL**

**Near Laguna Dam the topography is such that for 8,200 feet the canal must be carried on a fill. This is constructed of special material that is hauled in, spread in layers 6 inches thick, and then consolidated with sheep's-foot rollers, as shown in this picture. At a few other points fills are required to bring the canal up to grade; but throughout the remainder of the route cuts are made.**



# Henry Hudson Bridge

*R. G. Skerrett*

**SUPPORTING ARCH DURING CONSTRUCTION**

**One of the falsework bents that helped to support the arch during erection is shown in position on the south side of the river. The cage or grillage for another of the four bents is being lowered into the water.**

HISTORY, skillful engineering, and the needs of the hastening motorist conjointly broaden interest in the Henry Hudson Bridge over the Harlem River—the tidal link that separates the Borough of Manhattan from the Borough of The Bronx of Greater New York.

Tradition has it that it was close to the Manhattan anchorage of the new bridge that Henry Hudson had his first dealings with the Indians of Manhattan in 1609. The crossing extends from Inwood Hill Park on Manhattan to Spuyten Duyvil Parkway in The Bronx, and spans the Harlem near that stream's junction with the Hudson. It carries four traffic lanes; and along its west side there is a walkway slightly more than 4 feet wide. The floor system over the river is sustained by an apparently slender arch, which is unique in that it is the longest fixed steel arch that has been constructed up to date—the chord, from skewback to skewback at the opposing bridge anchorages, being 800 feet long.

As the Harlem is a navigable stream, which will probably be used often in the future by ocean-going steamers seeking a shorter route between the Hudson and the East rivers, the designers had to provide both ample width and height in the arch span. At its center, in midchannel, there is a clearance of 142.5 feet between the underside of the arch and the surface of the river at mean high water. The roadway is at an elevation 17.5 feet higher, and commands an outlook of great scenic charm.

The engineers have mastered a number of momentous problems in the planning of the bridge; and the fabricators and erectors of the steelwork likewise have shown skill and resourcefulness of a high order both in producing the multiple members and in rearing them without hampering the movements of vessels on the busy waterway or interfering with traffic on the great trunk-line railroad that runs beneath the structure on the north shore of the Harlem River.

The Henry Hudson Bridge forms a connection in a highway system, recently completed, that makes it possible for passenger motor vehicles to speed north and south without interference from local street traffic from end to end of Manhattan and close to the Hudson River waterfront for a total distance of 15 miles. The object, of course, is to reduce congestion in the busiest of the city's thoroughfares which has entailed, so it is authoritatively reported, a daily loss in time representing a toll of $500,000.

Instead of adopting the more common 2-hinged type of arch for so long a span, the consulting engineers chose a hingeless arch because of simplification in some features and certain structural economies. The fixed arch, however, imposed extremely exacting work in the fabrication shop, and called for nice control and the employment of special apparatus in erecting the arch members and finally bringing them together at the

crown so that they would meet precisely. The bridge consists of the channel arch, of two steel girder viaducts each 300 feet long, and of two massive concrete frame-and-wall approaches — the entire structure being 2,000 feet long and the associate steel sections having a combined length of 1,530 feet.

The spectacular arch is made up of two paralleling ribs set 50 feet apart on centers, and each rib is composed of two silicon-steel plate girders, 3 feet 8 inches apart, tied together by transverse lacing. Each girder is 12½ feet deep. The ribs of the arch are braced horizontally at intervals of 30 feet by a system of K-bracing that is as deep as the ribs. At both ends of the arch each rib is secured to a skewback which, in its turn, is attached to a massive steel grillage by means of 18 high-tensile-steel bolts 3 inches in diameter and 30 feet long. Eighteen feet of every bolt is embedded in the reinforced concrete of the anchorage that also grips and surrounds the grillage.

The skewback anchorages are keyed to the underlying bedrock and also serve as the foundation piers for the two main bridge towers each of which consists of two twin columns set 50 feet apart transversely, the same as the arch ribs. Between the towers the bridge-floor system is sustained by a series of spandrel columns that rise from each arch rib and are tied together transversely by steel lacing. The viaduct sections between the towers and the concrete abutments of the approaches are supported by steel columns resting on concrete piers that have been carried down to bedrock. The roadway pavement, which has a clear width of 42 feet, is of reinforced-concrete slabs 8 inches thick. Should traffic in the future warrant it, the bridge is designed to have an upper deck that will accommodate three traffic lanes and have a sidewalk along each flank.

After the grillage underlying each of the four skewbacks was set in its concrete anchorage, and the skewbacks had been bolted to all the grillages, then the exact distance between opposite skewbacks was ascertained to a nicety by surveying instruments. The precise measurements thus obtained guided the steelworkers in the fabrication of the rib sections and of the closing pieces that were to complete the two arch ribs when their adjacent ends came close to each other at the crown.

The arch-rib sections or, to be more exact, the different sections of the girders forming the two vertical sides of each of the ribs, were temporarily assembled on the ground of the fabricating shop to assure accuracy as to dimensions, fit, and curve. A test length of not less than 200 feet was maintained, and served as a basis of assembly. As an approved section was removed from one end of it, another section was added at the opposite end for checking and for making compensations where necessary to neutralize variations. After adjustment and inspection the bolted sections were separated and shipped to the bridge site for permanent erection. In this manner the prescribed curvature of the ribs was faithfully reproduced.

At the bridge site the ribs were progressively extended outward and upward from the skewbacks by the cantilever procedure. At two points on each side of the river, while this was in progress, the dead weight of the ribs was carried in part upon sustaining falsework bents, and each column of the four bents could be lifted or lowered by two powerful hydraulic jacks. Later, as the ribs projected beyond the two outer bents, they were stiffened longitudinally by toggle bents erected on top of them. These consisted of upright steel posts braced front and back on the line of the rib by eye-bar stays. Beneath each toggle post there were

**CLOSING THE ARCH**

**After the chords of the arch had almost met midway they were jacked apart 2½ feet. That operation served to raise their ends 4½ feet, thus bringing them to the prescribed final elevation. Into the opening thus made were inserted the closing sections. This picture shows the arch nearly finished, with jacking operations in progress at the center.**

hydraulic jacks that could raise the post and thus tauten the stays and offset any sagging of the lengthening rib.

The important pump that was connected with all the jacks was driven by compressed air; and the lifting and the lowering of the falsework bents and of the toggle bents reduced the stresses at the basic skewbacks and enabled the erectors to keep the rib sections vertically in line until the two halves of each rib were assembled with only a gap of about half a foot between them. Then came the climax of the operations—the critical job of completing each rib by inserting and fastening the crown plates on opposite sides of the box-girder structures. It should be recalled that as each section of a rib was added, it was secured by riveting on the connecting splice plates.

With the neighboring ends of each rib aligned vertically and horizontally, guides and jacks were installed to check lateral shifting. Two powerful jacks, one at the top and one at the bottom, were put in place between the ends of each rib to force them 2½ feet apart and, at the same time, to raise those members 4½ feet to the prescribed elevation for the purpose of interposing the closing pieces to complete the arch. Shims of steel plate were successively inserted to hold the rib ends apart while the jacks were being reset for another shove.

The functioning of all the jacks was directed by telephone from a single station on top the arch; and the crown jacks each exerted a maximum pressure of 1,000 tons on each rib. Because the structure was sensitive to temperature changes, and the work was done in July of the year gone, the climactic act was started at 5 o'clock in the morning, and six hours later the opening at the crown was just right for the insertion of the closing pieces. The work was concluded by 2:30 in the afternoon, with both ribs forming a perfect arc.

While the arch was being sprung across the river, the towers, the viaducts, and the concrete approach structures were carried forward; and as soon as the arch was completed, then was begun the erection of the surmounting spandrel columns and the construction of the floor system between the towers. The latter work was advanced from the north side of the river and pushed toward the tower that rises near the shore line of Inwood Hill Park. The bridge was finished by the end of last November and put in service in the first half of December, when the connecting Henry Hudson Parkway, on the south, was opened to traffic. The parkway, which is 4¼ miles long, affords a broad and typically modern link with other highways in the northwestern area of Manhattan, and especially with the extension of the upper section of Riverside Drive.

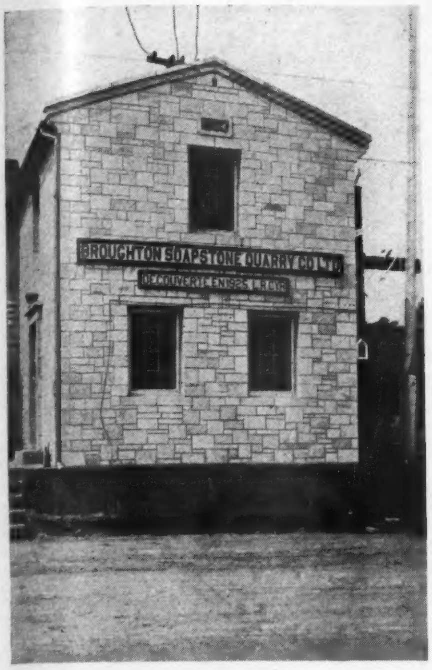
The bridge was designed by Robinson & Steinman, consulting engineers; the steel material was furnished by the Carnegie-Illinois Steel Corporation; and the superstructure was fabricated and erected by the American Bridge Company, a subsidiary of the United States Steel Corporation. The contract for the substructure was held by the Thomas Crimmins Contracting Company. The presiding official of the Henry Hudson Parkway Authority is Robert Moses, Park Commissioner of New York City. The Henry Hudson Bridge has been financed by a bond issue totaling $3,100,000; and the outlay will be refunded by tolls.

Traffic since the bridge was formally opened has proved that its construction was justified. During the first week a total of 69,587 vehicles crossed the structure, or an average of 9,941 a day, as compared with the official estimate of 7,000 daily, which represents the maximum figure. According to Mr. Moses, the indications are that 3,460,000 cars will use the bridge this year, although all financial requirements for 1937 would be met by toll collections from 2,690,000 vehicles.

**ERECTING ROADWAY**

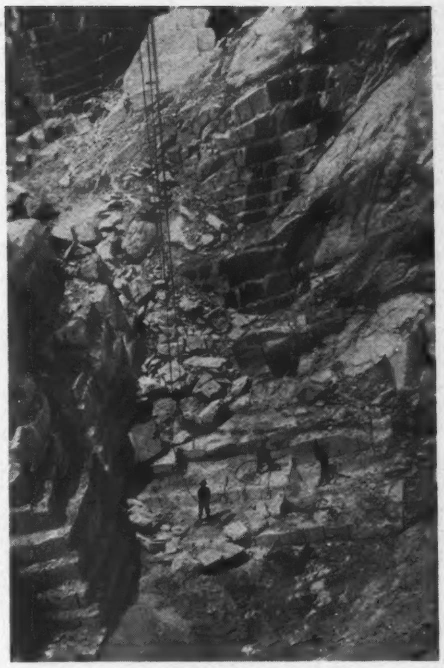
Here the arch is shown completed with the floor of the bridge in course of construction between the two towers. From skewback to skewback the arch has a length of 800 feet, exceeding in that respect any fixed steel arch previously built.

# Novelties from Soapstone




**ALL SOAPSTONE**

**From ground to roof, the office building is almost entirely soapstone. Inside, the floors, stairs, desk tops, stove, and many other articles of service are formed of the same material. Soapstone has been used abroad in some cathedrals.**



**QUARRY SCENE**

**Owing to the softness of the rock, drilling and blasting are not required. Blocks of stone are cut out with paving breakers and then hoisted to the surface, where they are sawed into the various sizes needed for commercial purposes.**

VARIOUS decorative as well as useful articles are made of soapstone; and their manufacture has been developed into an important side line by the Broughton Soapstone Quarry Company, Ltd., of Canada. An accompanying illustration shows some of these novelties, which find a ready sale in gift shops. For this particular purpose, stone containing impurities is most desirable because of its variegated coloring, whereas a purer stone that is consistently white is required for some of the more prosaic commercial applications.

In making the small objects, blocks of stone are first cut to the approximate shape of the articles that are being produced, and are then turned to finished form. After being polished they are coated with quick-drying shellac, which protects the surfaces and brings out the natural colors. The completed ware closely resembles marble in appearance.

Soapstone is a compact form of talc and usually occurs as the mineral steatite. It has a variety of uses, ranging all the way from refractories to face powder. It has a hardness of only one in the mineral scale and can therefore be readily fashioned into such things as book ends, inkwells, vases, and numerous other articles which are ornamental as well as useful.

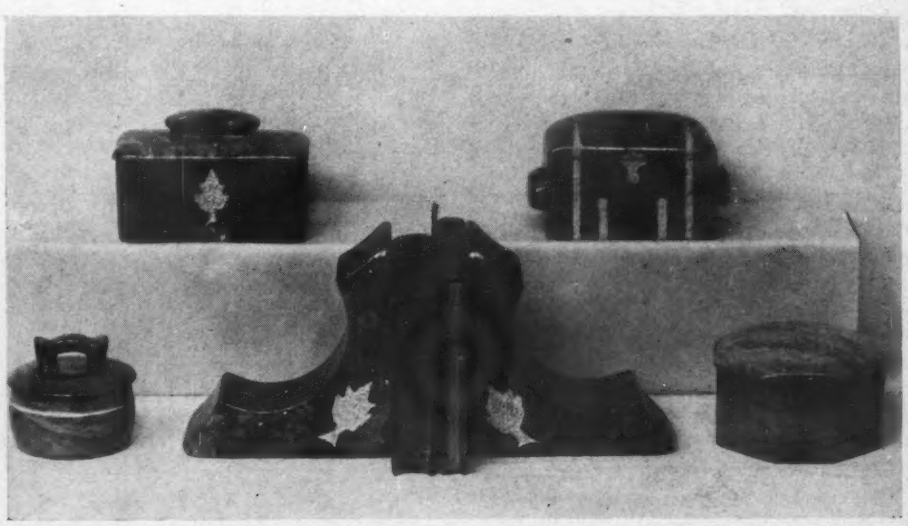
The Broughton quarry is operated by L. R. Cyr, who discovered the deposit in 1925. The workings are in the form of an open pit having a maximum depth of 85 feet, which is 25 feet lower than the hoisting level. Soapstone is one rock that requires very little drilling or blasting for its extraction. The usual procedure at the quarry in question is to cut it out in irregular blocks with air-operated paving breakers. These are loaded into steel stone-trays and raised to the surface by an electrically operated derrick.

The rough stone goes to the mill, where it is sawed into rectangular-shaped blocks that range in size from 2¼x4½x9 inches to 12x12x18 inches. Most of the blocks are used for lining furnaces because soapstone is highly resistant to heat and hardens when exposed to it. It also serves extensively as a filler for certain kinds of paper; and much of the output of the Broughton quarry is marketed to the Canadian paper and pulp industry.

Waste pieces from the cutting operations are consigned to Montreal for grinding into powder, provided the color is suitable. Off-color pieces and the dust from the saws are sold to the roofing trade. Stone of special shape is furnished for the making of monuments and mantels, as well as for interior trimming purposes. Talc pencils are produced from a softer variety of soapstone that is found in a neighboring quarry. The 1935 shipments of the Broughton Company consisted of 6,225 cubic feet of sawn stone, 244 tons of scrap, 119 tons of crude talc, 18 tons of powder, and 451 gross of pencils.

Soapstone is a hydrous silicate of magnesium. In order to lower transportation costs, the company last year installed a drier to remove its contained water; but this practice was abandoned when it was discovered that the blocks reabsorbed almost their original moisture content in transit and were as heavy upon delivery as they were before.

The offices of the company, adjoining the quarry, occupy a building of unique construction. From foundation to roof it is almost entirely of soapstone. This rock has been used in rearing some European structures, but never to the same extent. The interior of the office building is likewise composed largely of the product of the quarry. The stairs, floors, desk tops, inkwells, and even the stove are made of it. It is reported that soapstone absorbs sound to a high degree, imparting a soft and mellow tone to human voices and notably reducing the usual office noises such as the clatter of typewriters.



**ARTICLES MADE OF SOAPSTONE**

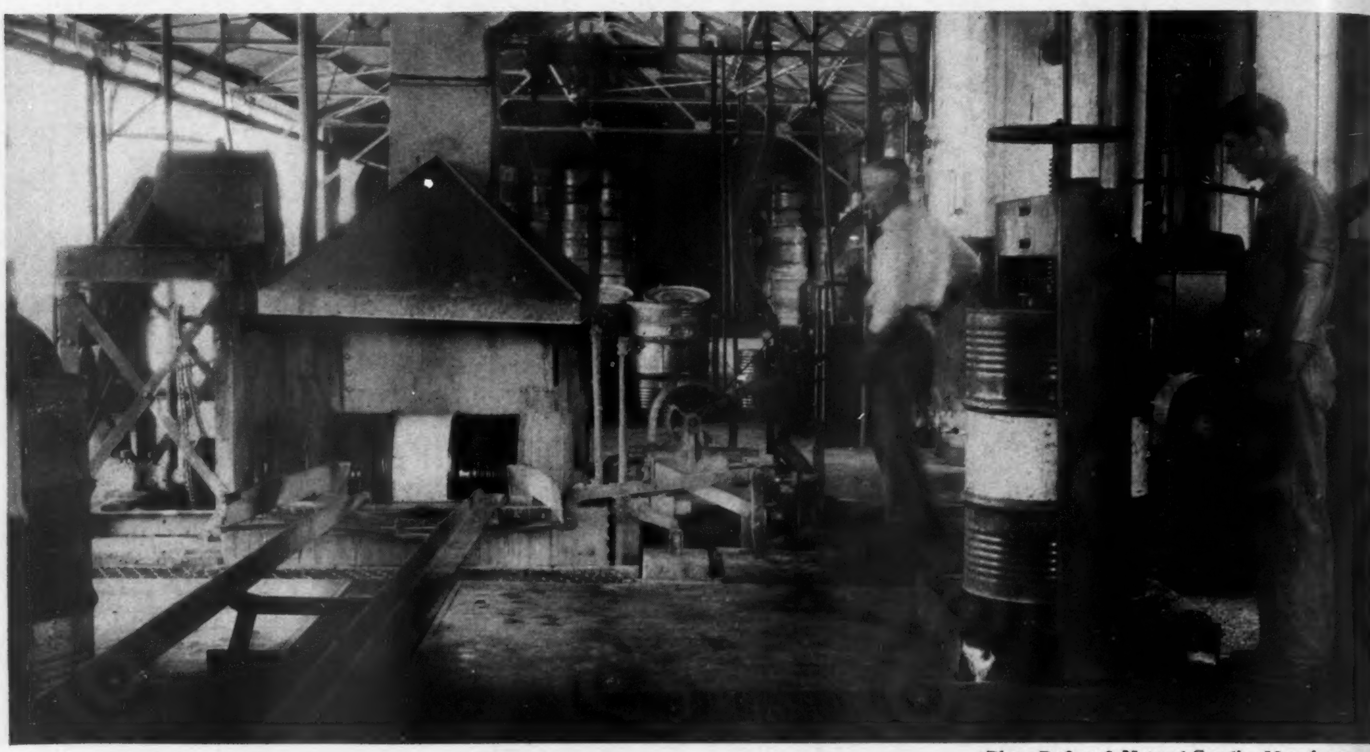


Photo Refiner & Natural Gasoline Manufacturer

**WHERE DRUMS ARE RECONDITIONED**

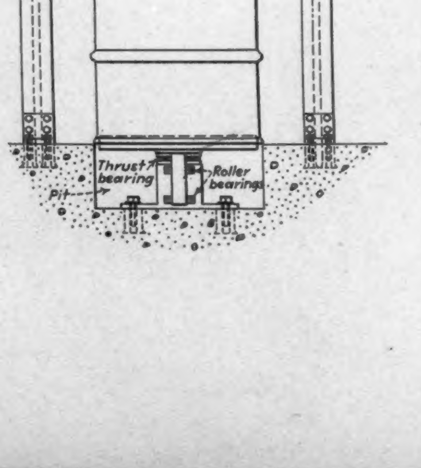
A section of the drum-overhauling plant of The Texas Company of California where metal oil barrels fit for re-use start their journey down the assembly line. At the left is a paint stripper and at the right a dedenter in operation. The practice here is to fill the drum with water and then to apply compressed air until a safe pressure is reached sufficient to snap out the dents. Those that refuse to budge are tapped with a rubber hammer around the edges to bring them back to shape. The water is subsequently siphoned out and wasted into a nearby drain. In the drawing at the bottom of the page are shown the structural features of a dedenting machine as built by The Vol-U-Meter Company, Inc.

# Taking the Dents Out of Metal Drums

RETURNABLE metal drums are the solution of the transportation problem, especially as it concerns the chemical and the oil industries with their destructive acids, alkalies, and inflammable liquids. Not only are they designed to meet the particular needs of each of the products carried but they are sufficiently sturdy to withstand the abuse which they encounter in transit. These containers vary in size—the largest having a capacity of 110 gallons and the one in most general use having a capacity of 55 gallons. Until they no longer warrant reconditioning they are refilled and reconsigned over and over again, thus offsetting their first cost.

When empty, the drums are returned to the shipper's plant. There they are inspected, and those found suitable are cleaned inside and out, repaired, and repainted, if they were originally finished in that way. Among the equipment used to expedite the work is a dedenting machine which, as the name implies, takes out any dents that may mar the appearance of a container. This machine is in the form of a press, and is provided with either crowned or flat top and bottom plates corresponding to the heads on the drums to be handled. These plates prevent the heads from bulging when pressure is applied.

With a drum in position and the top plate screwed down, pressure is exerted against its inner walls. This is done variously, depending upon shop practices and the type of container. In some cases—usually light-gauge drums—water only is employed. In other cases compressed air is admitted after the container has been filled with water, or compressed air only is used. This generally does not exceed around 80 pounds per square inch,




and must be applied gradually until the predetermined pressure is reached. This is necessary to prevent rupturing the drums, as they are not pressure vessels. Obdurate dents that will not yield to this treatment alone are removed by striking the edge of each with a hammer made of rubber, rawhide, or of wood. One blow, if it is well directed, is usually sufficient to cause a dent to snap out no matter how deep it may be.

From the experience of users, the returnable drum, whether light or heavy-gauge, has proved its practicability. For example, the Los Angeles case-and-package plant of The Texas Company of California is equipped to recondition 500 of them during a working shift. The life of such a container—during which it may make numerous trips to the repair shop—varies greatly and depends upon its construction, the product it is designed to carry, and the way it is handled in transit. However, according to estimates based upon actual service, a drum used to transport sulphuric acid (66°Bé.) may be expected to last anywhere from one to three years; one built to ship nitrocellulose cotton wet with alcohol, from ten to fifteen years; another designed for inflammable liquids, ten years and more; and an aqua-ammonia (26°Bé.) drum from ten to twenty years.

# Amphibian Vehicle Aids Oil Prospectors


ONE OF the strangest craft in existence is the Marsh Buggy, which has been created by the Gulf Oil Corporation to enable its geophysical crews to carry on their work in the swamps of Louisiana. This unique vehicle is a combination automobile, tractor, and boat, and can travel with equal ease on land, in waist-deep mire, or in deep water.

The Marsh Buggy weighs 7,500 pounds, is 22½ feet long, and is powered by a Ford V-8 engine equipped with an oversize cooling system. At the rear of the motor is a regular passenger-car transmission coupled in series with a McCormick-Deering tractor gear box. The tractor transmission is fastened rigidly to the frame, and the back wheels are mounted on the ends of extended axles. This dual transmission permits ten forward and six reverse speeds.

The front wheels receive their power from chains that pass over sprockets on the back axles. This gives a differential action between the wheels on either side but not between the front and rear. The tractor transmission is provided with two brakes: one to control the wheels on the right, the other to act upon those on the left. Thus, when operated in water, the huge machine can be propelled by all four wheels or by the two on either side. The forward axle is of the conventional type with regular toe-in and caster action, and the steering mechanism is similar to that of a motor car. The axle is pivoted in the center in such a manner that either front wheel can be raised 2 feet above its mate without distorting the frame.

The tires were designed and fabricated by the Goodyear Tire & Rubber Company Inc., and are the largest ever molded. They are 10 feet high and approximately 3 feet wide, and are mounted on 66-inch rims. The displacement of the balloons is so great that the monstrous amphibian floats with an immersion of less than 2 feet. Should one of the tires become punctured, constant pressure can be maintained by starting a compressor which feeds air into the tube. The compressor's output is sufficient to keep the balloons fully inflated until the vehicle can be returned to its base of operations, where the leaky tube can be repaired or replaced. It is interesting to note that the air pressure in the tires never exceeds 6 pounds per square inch, and that the buggy's weight is amply supported with only 1-pound-per-square-inch pressure in the casings.

In water or in marshes, traction is obtained by attaching twelve threads to each wheel. These are made of 2-inch rubber hose sealed at the ends and provided with air valves through which they are inflated to a pressure of 25 pounds per square inch to keep the links from flattening out under the weight of the vehicle.

To assure strength with lightness, aluminum alloys were used wherever possible in the construction of the Gulf Marsh Buggy. The main frame is an ordinary automobile chassis to which aluminum-alloy extensions have been added. The sides of the chassis and the platform for the men and paraphernalia also are constructed of this light, durable metal. The aluminum wheels are shaped like huge drums and contain sufficient air to keep the machine afloat even with all four tires completely deflated.

As the buggy frequently operates in inland waterways, it carries a marine license and all the equipment specified for Class 1 power boats. The white light, which must be visible throughout the horizon, is mounted on a mast at the rear of the vehicle and slightly above the top of the tires. The forward red and green lights, required by marine law to be visible throughout 180°, are fastened to a short bowsprit that may be folded against the prow when not in use.

At the back and at a point higher than the pilot's head is a small platform which serves on location as a stand for surveying instruments. At times, when traveling through marshes, one of the passengers is stationed there to direct the driver whose vision is frequently obstructed by marsh grass which often grows more than 12 feet high.

The buggy can be operated over smooth ground at a speed of 35 miles an hour, and is capable of navigating marshes at between 10 and 12 miles an hour. In water the speed is slightly in excess of 6 knots. When going over rough ground the huge tires act as cushions; consequently the men and their equipment are not jolted severely.

For centuries, transportation through the Louisiana marshes has been possible only by shallow-draft boats or by foot, neither of which permitted carrying the apparatus so essential to the scientist searching for oil-bearing strata. With the development of the Marsh Buggy, however, the picture has changed, and Gulf field crews are now able to negotiate the swamps with ease.

## Mobile Pug Mill for Roadbuilder

A COMPLAINT by the Ohio State Highway Department to the supplier of a quick-setting asphalt about the speed with which the material hardens took a rather unexpected turn. Instead of altering the property of its product, the maker suggested that the department gear up its machinery in keeping with the asphalt. The outcome is a new piece of roadbuilding equipment that not only overcomes the difficulty that led to the complaint but also facilitates the work and permits opening a road to traffic within a very short time.

The machine in question is a "walking pug mill," and was designed by the Jaeger Machine Company of Columbus, Ohio. It makes it possible to reverse the operations —that is, the aggregates are mixed after instead of before application. Following trucks that spread gravel or crushed stone, sand, and asphalt in proper proportions, the pug mill mixes the aggregates where they lie and levels the surface, which is then smoothed and compacted by heavy rollers that come along immediately behind. Reports have it that a road so constructed is ready for use ten minutes after rolling, and that from 2 to 4 miles of 20-foot pavement can be laid in a day. It lends itself especially well to highway repairs because it takes up but half of the roadway and quickly restores it to service.


### THE PETROLEUM OUTLOOK

AT RECURRING intervals during the past quarter-century fears have been expressed of a petroleum shortage in the United States. During the World War period, there was a flurry of experimentation with processes for extracting oil from oil shales, of which there are billions of tons in Utah and Colorado and lesser amounts in Kentucky. About that time, the rise in geophysics vastly increased the effectiveness of geologists searching for new oil fields; betterments in drilling equipment and in technique made it possible to obtain oil from deeper horizons; and improved refining methods increased the yield of gasoline from each barrel of crude. Between them, those three developments silenced the talk about a petroleum famine. Actually, the pendulum swung the other way; and the depression resulted in a surplus that had to be controlled by prorating production from individual wells.

A review of the 1936 activities of the petroleum industry shows that the time is still relatively remote when concern over crude-oil reserves need be felt. Production in the United States reached an all-time peak of 1,090,000,000 barrels, which was approximately 63 per cent of the world output. During the year, largely because of the application of scientific exploratory methods, 50 new fields were discovered. As an indication of the vigor with which this search for virgin territory is being prosecuted, it may be mentioned that the industry spent $14,000,000 during 1936 for geophysical prospecting. The drilling of new wells aggregated 74,000,000 feet, or sufficient to make a hole through the center of the earth and another one half way through.

It is significant that the public bought these petroleum products at an average price considerably lower than that charged for them in 1929, and that the industry as a whole was still able to make 7 per cent on its capital investment. Much of this favorable showing may be attributed to research. Proof of this is found in the fact that those products amounted to 65,000,000 barrels more than in 1929 but cost consumers $500,000,000 less, although wages in the industry were maintained.

### MARINE MINING

WE ARE continually learning more about the continental fringe of the United States, and much of the information promises to become of economic significance. Apparently, the vast mineral resources of our nation invade Neptune's domain; and in their exploitation we may see the development of strange marine equipment.

For many years coal has been recovered from beneath the sea in the Maritime Provinces of Canada; but the attack has been entirely subterranean, galleries having been extended out from openings made on the shore. Again, in California, where the tidal plains are estimated to contain $2,000,000,000 worth of petroleum, many inclined wells have been put down, enabling rigs to be located on dry land even though production is coming from offshore areas. A few operations are conducted from piers or other structures rising from the sea floor; and this procedure will no doubt be followed more generally as the distance from the coast increases.

Dr. Francis T. Shepard, of the geology department of the University of Illinois, reported recently that a range of salt domes, 180 miles long, had been found in the Gulf of Mexico; and added that they may safely be assumed to be as rich in oil, salt, and sulphur as similar structures on the mainland in Texas and Louisiana. Their depth below water is such, however, that special methods will have to be devised for exploiting them.

The discovery of this chain of domes was made by accident while exploring a sunken canyon. Subaqueous channels of this kind were either cut before the ocean advanced or the land subsided, and exist at various points along our shores. Several were recently found off California; but the largest known is the inundated gorge of the Hudson River that extends seaward past Sandy Hook. Formed probably in part by glacial ice and in part by water, this V-shaped canyon has sides that reach to a depth of 4,000 feet.

### COLORADO VERSUS NILE

IN THIS issue we present an article concerning one of the important but little-known features of the Boulder Canyon Project. It is the All-American Canal. In many minds the belief still persists that the generation of power is the chief purpose of Boulder Dam. This is, of course, contrary to fact, the truth being that the power plant was sort of tacked on to pay the construction bill. The primary reason for building the dam was to control the Colorado River—to prevent floods and droughts and to trap silt.

Agitation for the dam originated in Imperial Valley, and that great agricultural area continued its appeal for many years. Probably it never would have been successful had not Los Angeles added its voice; but the fact remains that it was the benefits which were to accrue to Imperial Valley that became the basis upon which rested the principal argument for passage of the enabling legislation.

With Boulder Dam in operation, the valley has reaped part of its expected advantage. The flood menace has been removed. For the remainder of the favoring effect it must await the completion of the All-American Canal. With contractors probably moving dirt faster than it has ever been moved before, the indications are that the 85-mile-long ditch will be in service before many more months have passed. The job itself is not spectacular; but some of the equipment in use there is of decided interest to construction men.

By chance, we have in this issue an account of some of the construction methods of the ancients. The two articles should form a striking contrast of new and old methods and machines.

# Pittsburgh Experimental Mine Celebrates Anniversary

ABOUT twenty-five years ago, Dr. George S. Rice, of the U. S. Bureau of Mines, demonstrated the fact that coal dust was primarily responsible for the disastrous explosions then occurring with alarming frequency in bituminous collieries in the United States and elsewhere. That marked the beginning of the Government's experimental mine on the outskirts of Pittsburgh, Pa. At that time the idea that coal dust, unaided by fire damp, could propagate a violent explosion was generally scoffed at, so to prove his point and to awaken operators to the existing dangers, Doctor Rice began to study the causes of coal-mine explosions. As a colliery with just the right conditions for his experiments was not available, he obtained permission from the late Dr. J. A. Holmes, first director of the U. S. Bureau of Mines, to take over a coal outcrop near Pittsburgh and to convert it into a laboratory.

There, on October 30, 1911, Doctor Rice staged his first public demonstration, which was witnessed by 1,500 persons, including mine owners and Federal and State officials. What those men saw, to quote *Mineral Trade Notes*, was a "searing flame of a violent explosion shot out of the mine opening 600 feet across the valley, destroying trees and everything in its path, thereby demonstrating without a shadow of a doubt that coal dust alone could propagate into a widespread disaster."

In the intervening years, a long series of similar tests—1,536 of them, in fact—have been conducted, and Doctor Rice has found time to devote his attention to another aspect of the problem, that of preventing coal-dust explosions. He has been instrumental in formulating scientifically accurate specifications for rock dust, which is now in general use in bituminous collieries where it is scattered variously over all exposed surfaces not only as a preventive against explosions but, in cases where they actually occur, to check the spread of the flames.

The question has been asked, How many lives have been saved by rock-dusting in coal mines? No one can say; but enough incipient explosions are known to have been stopped by means of it to warrant the conservative statement that thousands owe their lives to Doctor Rice's work in the Bureau of Mines. For this he has been rightly called the father of rock-dusting in this country. In order to commemorate his pioneer efforts and the first test that led to the introduction of this important safety measure, another demonstration of the explosibility of coal dust was held in October of 1936 on the very spot where the original one was staged and where the present Pittsburgh Experimental Mine is now located.

## GUNITING LARGE PIPE SECTIONS IN PALMLAND

**WHILE workmen are speeding the construction of the Colorado River Aqueduct which will carry water from the Colorado River to thirteen cities in southern California, the Los Angeles Metropolitan Water District is making ready to distribute it to points of use.**

**A link in this distribution system will take the form of an inverted siphon between the towns of Arlington and Fontana, and is now being built under contract. It will consist of 54,530 feet, or about 10½ miles, of steel pipe having an inside diameter of 10½ feet. At the low point in the siphon the head will be around 200 feet, and very heavy pipe is accordingly being laid—the thickness increasing 1/32 inch at a time as greater depth is progressively reached.**

**The steel pipe is delivered in sections 33 feet long, untreated except for an exterior coat of white paint and an interior one of black. At the contractor's yard, near Arlington, the lengths are prepared for installation and are then loaded on heavy trailers for hauling to their final location points. The treatment consists of applying a ¾-inch layer of concrete to a reinforcement of meshed-wire fencing by the guniting method. In the foreground of the picture is one of the unfinished pipe sections: at the left a workman is seen operating a cement gun. Air for this work is supplied by the Type XL, 500-cfm. portable compressor shown.**

**Of interest are the three varieties of palm trees forming the background for the picture. The tallest one is a fan palm, a species that attains a height of 150 feet. The second tallest is a Washingtonia palm, which is native to southern California. It seldom grows higher than 50 feet. The others, with the long fronds, are date palms. They grow 40 or 50 feet high in all parts of southern California except in the high mountains; but bear fruit in commercial quantities only in areas of extreme heat such as the Coachella Valley where the temperature reaches 130°F.**

# Industrial Notes

Half bricks are being manufactured as a regular thing at a kiln in Leeds, England. Not a bad idea when one recalls how often a stonemason has to break a brick of standard size because the space to be filled is too small to accommodate it.

For an engine that it is building to operate on paraffin, the Coventry Victor Motor Company of Coventry, England, claims smooth running and an increase in power output, as compared with gasoline, of as much as 10 per cent.

An increase in the use of asbestos may be expected as the result of recent improvements in the weaving and dyeing of this noninflammable material. Among the articles to be made of it are listed window and drop curtains, rugs, paneling, wall covering, etc.

Metal stampings and other work with sharp edges are the cause of many arm injuries that can be prevented if the men handling them will wear leather sleeves reaching from the wrist to the elbow. One well-known automobile plant has made their use compulsory, and as a result has largely eliminated cuts of this kind.

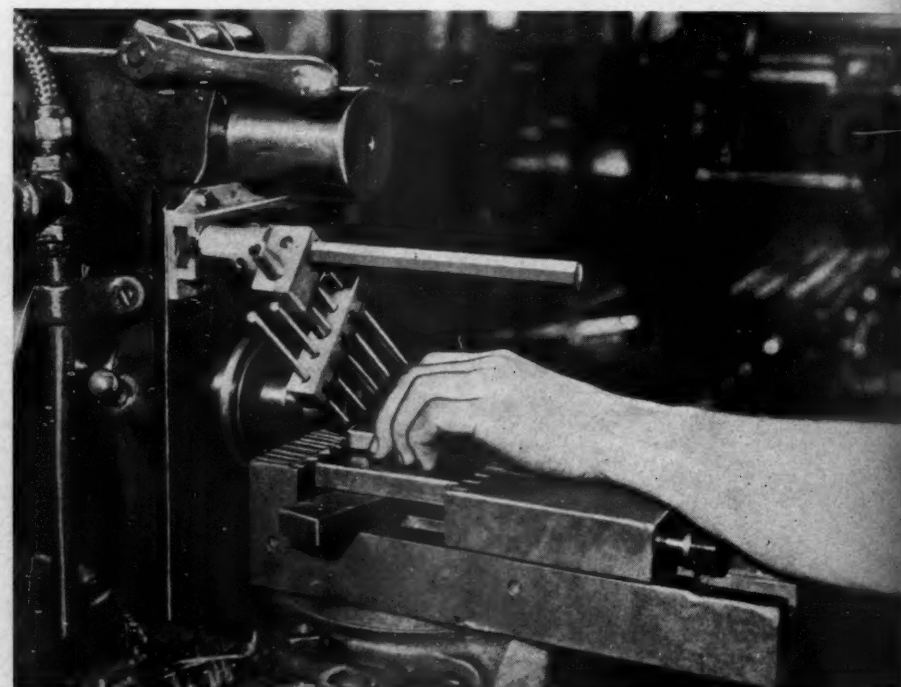
Laboratory workers of the General Electric Company have succeeded in welding together two pieces of alloy, one of Copnic and the other of Chromel, and in rolling the strip to a thickness of six millionths of an inch. Gold has been beaten to four millionths of an inch and aluminum to ten millionths of an inch; but this is the first time two alloys have been so united and then reduced to a section of such thinness. The weld in the ultrathin bimetallic foil, even when magnified 250 times, can be distinguished only by the difference in color between the two alloys.

Beautiful decorative effects in porcelain enamel and metal can be obtained by a finishing process of recent development. The underlying surfaces are prepared in the usual way with a ground coat of enamel which may or may not be fused before molten metal is sprayed on top of it. Subsequent exposure to heat causes the materials to blend. If designs are desired, stencils are affixed before the metal is applied. The method makes it possible to produce a wide range of highly colorful and artistic finishes.

Managers of large concerns that want to keep their fingers on the pulse of all their departments through personal contact can do so from their desks if they will provide themselves with offices such as those being built for the heads of Bata, A.S., the largest shoe manufacturer in Czechoslovakia. That company is constructing a 15-story building—the country's first skyscraper—which is to house its administrative offices. The outstanding feature of this structure is the elevator system for the executives' offices—spacious rooms, in keeping with their positions, that can be raised and lowered so as to put them in immediate touch with any floor in the building. The latter will be 213 feet high and constructed of steel and glass.

Rust-prevention is a problem that is still engaging the attention of engineers despite the many means and methods that have been developed to protect metals against corrosion which, it has been estimated, takes an annual toll of $1,000,000,000 in the United States alone. According to information recently published by the U. S. Bureau of Mines, two British engineers have invented a process of an electrochemical nature that is said to be revolutionary. By it an electric current is passed through a suitable medium, breaking down its metal content into simple elements or compounds. These penetrate the surfaces of the metal being treated to a certain depth and, in combination with the latter, form a protective alloy. Assuming, for example, that the medium is copper and the object a piece of sheet iron, the result will be a true iron-copper alloy.

The interest of mining circles is centered on the old Centennial District in Wyoming because of the discovery there of what is claimed to be an exceptionally rich deposit of minerals of the platinum group. The ore occurs in veins which are traceable on the surface for a distance of 3 miles and vary in width from 20 to 70 feet. A dozen or so properties in the region have been worked for gold, while the far higher-grade minerals have been discarded because the ores were considered worthless or could not be treated by existing methods. Numerous assays have been made, and all indicate the presence, in paying quantities, of iridium, osmium, palladium, platinum, rhodium, and gold. Engineers who have examined the deposit are of the opinion that it shows every sign of being one of the most important discoveries in the platinum group in the century.



FREE FINGER INSURANCE

An announcement of interest to American industry generally has been made recently by the officials of the International Business Machines Corporation of New York, N. Y. Proud of the fact that its factory, with its 3,700 employees, has to its credit 2,319,731 continuous man-hours without a lost-time accident primarily because of the judicious use of safety-first devices, that company is offering free of charge to plants and shops in the United States drawings and specifications of an adjustable guard for milling machines that will protect the operator's fingers from injury.

The guard is the invention of R. E. Frederick, one of the corporation's foremen, and was demonstrated by him at the last convention of the National Safety Congress held in Atlantic City. It consists of ¼-inch steel pins of varying lengths held by screws in a T-slot plate which is fastened on the column between the arbor support arm and the spindle. The entire guard may be moved horizontally to cover the cutters regardless of the position of the machine, or two or three can be mounted side by side if the milling operations are such as to call for the protection of a wider area.

From the standpoint of production, the device has proved a help and not a hindrance because it can be easily applied and quickly adjusted and because of the confidence with which the men do their work. Since the announcement was first made many concerns have taken advantage of this generous offer.